AGRICULTURAL ENGINEERING

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AGRICULTURAL ENGINEERING

Volume 12 AUGUST, 1931 Number 8

The Function of the Extension Engineer in the Reorganization of Agriculture[1]

By B. B. Robb[2]

B. B. Robb

TO FORECAST the future is merely to make a guess as to what will come to pass. Anyone can guess. Where there is no precedent, or previous experience, one person's guess is as good as another's. The best forecasts are usually made by those who have studied past changes and the causes contributing thereto, and who use such studies as a basis for projecting the future. In order to set forth what part will be taken by the extension agricultural engineer in relieving the present agricultural situation, it seems best to attempt, first, to outline as accurately as possible what we mean by the present agricultural situation, and, next, to determine what seems to be the possible general economic solution of this situation and finally to outline the role to be played by the extension agricultural engineer in bringing about the desired changes.

THE PRESENT AGRICULTURAL SITUATION

Unquestionably the best source of information we have on the present agricultural situation is furnished us by the agricultural economist. In attempting to outline this situation and in discussing some of the problems growing out of it, as they apply to the work of the agricultural engineer, free use has been made of information gathered under the direction of Dr. G. F. Warren, by the department of agricultural economics and farm management at Cornell University and supplied through the cooperation of Dr. V. B. Hart.

Different persons have attributed the present agricultural depression to different causes. Of the many theories advanced, Dr. Warren points out that three are worthy of consideration:

1. German economists, for example, attribute the depression to the large population in their country with a low purchasing power. They say that the depression is due to the inability of the German people to buy.

2. Most English economists attribute the depression to a general decline in world prices due to a low production of gold and a high demand for it, thus causing gold to increase in value when measured in the amount of goods that an ounce of it will buy. This is another way of saying that the production of gold has not kept pace with the production of other things. The world's business has simply been increasing faster than the supply of gold with which business is done. Therefore, gold has become relatively scarce and more valuable. Seen through an engineer's eyes the situation is the same as when we have a large amount of construction work being done in a city where there is only one power shovel, and because there is a lot of work for that one shovel, men are willing to pay highly for its use.

3. In our own country, many persons have difficulty in selling their products at satisfactory prices; and so have said that the depression is caused by overproduction.

A few comments on this matter of alleged overproduction which we have heard so much during the last few years seem to be in order. There has never been a time when there was not a surplus of something, nor a time when there was not a shortage of something. Last year there was a surplus of wheat and a shortage of corn. We have recently seen a surplus of sheep and cattle and a shortage of hogs. We have never seen, however, a surplus of all things or a shortage of all things at the same time.

There have been three times since the year 1800 when we have had a great war and economic conditions very similar to those through which we have been going since the World War. During the deflation period following the Napoleonic wars, prices in England dropped from a level of 211 per cent of prewar in 1814 to 128 per cent in 1824. The general price level in England thus declined nearly one-half in ten years. Following our own war of 1812, the general price level of this country declined from an index of 250 per cent of prewar in 1814 to 115 in 1824. In this country, as in England, prices declined about one-half in ten years. A similar drop followed our Civil War when prices fell from an index of 209 in 1864 to one of 114 in 1874. Coming on down to our World War period, in May 1920 the general price level in this country was 244 per cent of prewar. Last October the general price level had dropped to 121 per cent of prewar. Just as happened in other post-war periods, prices declined about one-half in ten years. In each of these cases, the popular explanation of the drop in prices was overproduction. It was difficult to sell things at the old prices, and because a large supply is one of the reasons why it is sometimes difficult to sell goods, the tendency has always been to assume the major cause of the drop in prices to be overproduction.

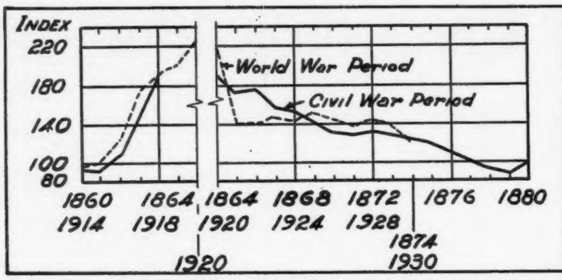
A quotation from a paper recently prepared by an agricultural economist is pertinent at this point:

"The long time effects of deflation should not be confused with business cycles. At present we are in a recession period of a business cycle, but this is superimposed on a very severe depression due to deflating to a lower price level. This makes the present depression doubly severe."

Those who ascribe overproduction as the cause of the present economic situation should be reminded that in the ten-year period, 1919-1929, the acreage of 38 food and feed crops deceased one per cent. During this same period, population increased 16 per cent. Substitution of gasoline power for horse power (in the form of tractors) has reduced the demand for feed crops somewhat. This substitution has released about eight per cent of the area in

[1]Paper presented at the 25th annual meeting of the American Society of Agricultural Engineers, at Ames, Iowa, June 1931.

[2]Professor of agricultural engineering, Cornell University. Mem. A.S.A.E.



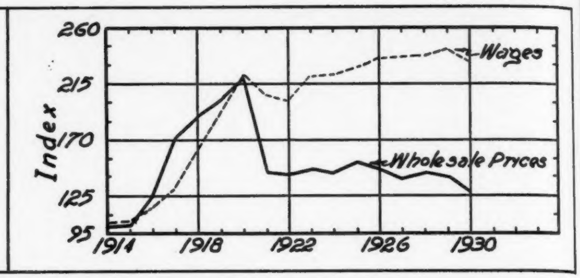


Fig. 1. (Left) Wholesale prices in World War and Civil War periods (five years before each war = 100), from Warren, G. F., and Pearson, F. A., "Farm Economics," p. 1428, November, 1930. Fig. 2. (Right) Wholesale prices and wages in the United States in the World War period (1910 to 1914 = 100). Prices reached a peak nine years later, according to United States Bureau of Labor Statistics index of wholesale prices of all commodities converted to the five-year base, 1910-14 = 100, and weekly earnings of New York factory workers from data furnished by Department of Labor of New York, and as published by Warren, G. F., and Pearson, F. A., in "Farm Economics," New York State College of Agriculture, No. 68, p. 1438, November, 1930

crops other than cotton. The net result of this change in demand and decrease in crop area is equivalent to an increase in acreage of approximately seven per cent of our food and feed crops, while our population has increased 16 per cent. Our crop yields per acre for these crops are about the same as they were ten years ago. This last year, for example, the yield of 17 principal crops (including cotton) was five per cent below the ten-year average. The production of these crops per capita was 13 per cent below the ten-year average, and this last year more than ever before, we heard overproduction given as the cause of the agricultural depression.

In the face of these facts it would appear that general overproduction is not the cause of the present depression.

Probably the most important economic problem facing farmers at the present time is what is known as "the lag in wages." Whenever prices rise rapidly, wages rise somewhat but tend to lag behind. Whenever prices fall rapidly, wages tend either to fall less rapidly or not to fall at all. We have had some drop in wages during the past year, but wages have not dropped as much as the price of commodities, and this is exactly the way things worked out in other post-war periods.

When the general price level was going up in 1914-1920, wages went up but not as fast as other things, and since 1920 when the general price level has been tending to return to prewar, wages have stayed relatively high. Exactly the same situation prevailed during and following the Napoleonic wars, the War of 1812, and the Civil War. The price of labor seems to change less rapidly than the price of other things that men buy and sell. This means, therefore, that wages are likely to be relatively high as compared to other things for some time to come.

Due to this lag in the change of wages, whenever prices rise or fall, freight rates and handling charges change slowly. Distributing charges are nothing more or less than someone's wages. Therefore, when prices rise rapidly distribution charges lag behind just like the cost of labor, and in a post war period of a declining price level, distribution charges stay relatively high. These relatively high returns for the distribution of products are generally received by persons living in cities. This means that a period of general declining prices results in transferring a large amount of money from the country to the city. Our city cousins, except for those on fixed salaries, therefore, have generally more money to spend than do our friends on the farms. One of the ways, in addition to buying gasoline, in which city persons have attempted to spend this extra income during our last period of deflation, has been in building houses. The man who had been living in a six-room house and found he had a larger income, decided that a six-room house was too small so he built a ten-room house. His six-room bungalow passed into the hands of a family that had been living in a four-room apartment. Hence, the building boom. And following every other important post-war period with its declining price level, relatively high wages and cheap food, we have always had a building boom, and they all have eventually broken.

Another effect of the relatively high wages which the average city consumer has been having, as compared with the price of food, has meant that he has been in a position to buy the more choice grades of farm products. There are two factors involved in this increased demand for better grades of products—the relatively high purchasing ability of the consumer, and the relatively high handling charges. High freight rates and handling charges have been forcing the producers in the Pacific northwest to ship a very high quality egg and high quality apple to the eastern markets. Low-grade products would not pay the high freight rates. Therefore, middle western and eastern products have been facing an increasing competition on quality goods from the more distant producers.

The present agricultural situation then may be summarized as follows:

1. We are in the midst of what is probably the worst depression this country has ever experienced.
2. Farm prices are low as compared with prices of commodities that farmers have to buy.
3. The cause of the depression is not a general overproduction.
4. Labor is relatively high and probably will continue to be so.
5. Transportation charges are high.
6. High labor and high freight rates have transferred money from country to city which together with cheap food have produced a building boom and a demand for quality products.
7. The present condition is essentially a type of situation that has occurred several times previously.

In support of what has been said about the similarity of the present economic situation to those that followed other wars, and in order that you may draw your own conclusions as to whether or not it seems reasonable to expect that prices are likely to continue low and wages to continue relatively high, there are submitted for your consideration two graphs. In the first (Fig. 1) is a curve showing the general price level in the United States for the World War period, superimposed on a similar curve for the Civil War period.

The second graph (Fig. 2) shows the way in which wages lagged when prices were going up and going down during and following the World War period. A similar picture would be shown in graphs representing the general price level and wages during and following the Napoleonic wars period, or the Civil War, or the War of 1812.

THE ECONOMIC SOLUTION

The economists see two ways in which the farmers can meet this general situation:

1. Reduce production until prices rise.
2. Reduce costs.

If the price of a single product is far below the general level of prices, there is certainly a need for extensive reduction in the production of this particular product. However, if as has happened recently, the prices of all things

that a group of people are selling are low compared with wages and other things which they have to purchase, the real and only practical remedy is to bring production costs down to where they correspond to the prices of the goods that are sold.

City business men frequently ask why farmers do not stop producing until they get a satisfactory price. As engineers, we know that when the management of a factory finds it is not selling its production, it can close down and throw the burden of the situation on its employees. Agriculture, on the other hand, is both a biological industry and a home industry. The farmer has not yet figured out how he can push a button and stop a yearling heifer or a pen of shoats from growing. The factory owner can stop buying raw materials and putting them through his machines. If the farmer does this, the heifer and pen of shoats die. Also, if the farmer shuts down his factory and tries to throw the burden on the employees, he is stepping on his own toes, for on the majority of farms, the manager and employee are the same man.

From the standpoint of both the engineer and the agricultural economist, the most important problem facing the American farmer at the present time is that of "relatively high priced labor," and, as has been pointed out, there is every indication that we can expect wages to be relatively high compared to other things for sometime to come. Now what does this mean? It most certainly means that farmers must produce things with less labor per unit of product —less labor per hundred-weight of milk, less labor per bushel of potatoes and less labor per bushel of corn.

One of the ways in which farmers are going to increase their production per man-hour of labor is by buying only land or working only land that brings them a high return per hour. This situation also means more than ever before the need of a farm business large enough to keep the farmer and his labor supply profitably employed throughout the day and throughout the year. This reference to a good-sized farm business means two things from the standpoint of the agricultural engineer. It means, first, that with a large sized business there is a need of more labor-saving machinery. It also means that, with the rapid development we have had in labor-saving farm equipment, the farmer needs a large enough business to warrant the ownership of the newer labor-saving machines and of larger units of some of the older ones. The retail price of farm machinery is now high. But a machine that saves labor is saving one of the most expensive factors of production. This again means larger farm business to reduce the overhead charge on machinery.

Another very important way in which farmers are adjusting their business to meet the present situation is by finding ways of reducing costs of distribution. Relatively high cost of distributing farm products and of distributing farm supplies hits the farmers in two ways. Relatively high distributing charges mean that retail prices are high compared to wholesale prices. Agriculture, for the most part, buys at retail and sells at wholesale. Relatively high freight rates and handling charges are taken out of the price that the farmer gets for his product and added to the price he pays for his farm machinery, fertilizer and other supplies.

The individual farmer can often reduce some of the costs of distribution by the use of his own truck or by having incoming farm supplies or outgoing farm products handled by the trucks of his neighbors. This last statement should not be construed to mean that I believe that farm products and farm supplies can necessarily be transported at less cost by truck than by railroad. However, whenever a farmer uses his own truck to market some farm products or to bring in some farm supplies, he is getting a little slice of those high distributing charges.

Another adjustment is that of increasing the quality of farm products to meet the demand for high quality and high grades that have been built up among the consuming public as a result of a high purchasing power. The production of a higher quality apple, a higher quality egg, a higher quality of milk and in general the production and marketing of higher grades and qualities of all farm products are making increased demands for changes and improvements in farm machinery and other equipment. Any way by which we, as agricultural engineers, can assist farmers in the production of a higher quality product is sound action from both an engineering and an economic standpoint.

FUNCTION OF THE EXTENSION AGRICULTURAL ENGINEER

Now let us see where the extension agricultural engineer fits into this economic picture. First, he must familiarize himself with economic conditions existing in his particular state or country, not only by personal observation and study, but by familiarizing himself with the results of the research work being done by agricultural economists. We, as engineers, have for years been accustomed to depend upon the findings of scientific engineering research. In this period of desperate need for rapid agricultural adjustments, the agricultural engineers must in a similar way depend upon the findings of the agricultural economist.

When labor was cheap it was not a great error if we recommended the use of a machine or method of handling a machine that was only 75 per cent as efficient in the use of man labor as another machine or method. However, with present labor costs and present prices of farm products the agricultural engineer has a decided responsibility in making recommendations that are sound from the standpoint of labor efficiency. He must also study carefully the programs of other divisions of agriculture such as the field of agronomy, the field of dairying and the field of horticulture, plant breeding, plant pathology, rural sociology and others to determine how to lay out a program that will be coordinated in every way with the efforts of persons working in these other fields.

This will obviate unjust criticism of what other extension workers are recommending.

The agronomists tell us that one of the ways of producing more per unit of labor is by the use of better seeds and improved varieties. They also tell us that yield is closely correlated with the proper preparation of the seedbed. This, in turn, is frequently dependent upon the plowing and cultivation of the soil at exactly the proper time. This means that it is of decided advantage to the farmer to have the best equipment and in good condition to make the best possible use of time when the soil is in the most suitable condition to work.

Both economists and agronomists tell us that fertilizer and lime are cheap as compared with labor and that farmers can afford to use more commercial fertilizer and more lime on the good land than formerly in order to save on labor. This saving of labor is brought about by increasing the yield per acre and in this way the yield per hour of labor. This, of course, brings up the problem of better and larger units of machinery for the distribution of fertilizer and lime.

One very important way in whch farmers are adjusting their businesses to meet the present high cost of labor is by the use of two or more row cultivators; by the use of modern harvesting machinery, and by the use of larger and heavier disking and harrowing machinery to replace plowing. Here the extension agricultural engineer finds the opportunity to give information and instruction on the use, maintenance and the repairs of (1) tractors, (2) tillage machinery, (3) machinery for distributing fertilizer, (4) seeding machinery, (5) cultivators, (6) harvesting machinery, and (7) haying machinery.

The dairymen and poultrymen who are trying to get higher production per cow or per hen in order to produce their products with less labor per unit, are dependent upon the extension agricultural engineer for assistance on problems of structures and mechanical equipment. The engineering problem of structures includes the erection of new buildings and the remodeling of old ones. In this respect, caution should be exercised in recommending the erection of new buildings. Most of our buildings on farms were

put up when lumber and labor were much cheaper than at present. Because of the present price of lumber and labor it would cost more to rebuild the barns and houses on many farms, especially in the East, than the entire farms would sell for. Frequently, from an economic standpoint, when a farmer has a fire, it is cheaper for him to buy another farm with the buildings on it than to rebuild on the ruins of the old ones.

In assisting livestock men in getting a higher production per animal and per hour of labor, we are faced with the problems of mechanical equipment such as (1) water supply, (2) milking machine, (3) refrigeration and milk cooling, (4) stanchions, feed and litter carriers, (5) automatic feeders, (6) feed grinders, (7) ensilage cutters, and (8) manure spreaders, etc.

The horticulturists, the entomologists and the plant pathologists will probably write into the general extension program that more and better fruits and vegetables must be produced per unit of labor.

Here the extension agricultural engineer will find a machinery problem involving tractors, tillage, and seeding machines, spraying, harvesting, grading and refrigerating machinery, as well as roadside stands and storages, all of which will fall within the machinery and structures program.

In planning the extension agricultural engineering program, specialists should first study carefully the farmers' economic problems to determine how and where the application of the science of engineering can aid them in making needed adjustments in their businesses. While we have been speaking more of economic adjustments than of any other kind, there are, of course, needed social adjustments on which the agricultural engineer can render valuable service. Not all the income that a farm family receives can be measured in dollars and cents. If by the application of engineering principles we can assist a farm family in getting more pleasure out of their electric lights, their radio, or their water system, we are rendering a most valuable service.

Many of the rural economic and social problems in which the extension engineer has a part cannot be solved in the light of existing knowledge. This means a responsibility on the part of the agricultural engineer for taking these problems to the research men and aiding in the guiding of research work. All too often much agricultural engineering research work has been based on the personal interest or inclination of the man doing the work rather than on the actual need of the farm people. In deciding which piece of research work should be done first, consideration should be given to the needs of farmers rather than to the personal inclination and interests of the research worker. The extension agricultural engineer is in an excellent position to assist in bringing about the basing of research work more on the actual needs of farmers.

When we write into the general extension program that one of the ways to better the present agricultural situation is by bringing about the more efficient use of farm machinery, we mean the efficient use of machinery already on our farms and, in many cases, assisting in bringing into use of new machinery, or at least making needed improvements on already existing machines.

The efficient use of a machine is much more than the mere ability to operate the machine in question. It means that the farmers should have an adequate knowledge of its care, repair and adjustments. It also means that the farmers should have a knowledge of accessories and additional parts that may be added and also the ability to judge when, from the economic standpoint, it is advisable to scrap the machine for a larger or better model.

The efficient use of modern farm machinery calls for larger and more regular-shaped fields and for fields that are free from such obstructions as stumps, rocks or wet spots. A few years ago much was said and written about the desirability of clearing up hedgerows and fences in order to bring more land into cultivation. This was when labor was cheap. Few farmers can, at the present time, afford to do this work in order to get more land. Land is cheap but labor is high. However, the removal of stumps, rocks, hedgerows and unnecessary fences or the draining of wet spots in otherwise clear fields in order to make possible the use of larger units of machinery, is good farm management practice.

From both the economic and engineering standpoint the situation which we have of relatively high transportation charges means the need for the following:

1. The production of bulky and perishable farm products as near as possible to markets.
2. From an individual farmer's standpoint the production for local market or retail trade.
3. The delivering of products to market and to consumer as much as possible by the farmer's own auto or truck.

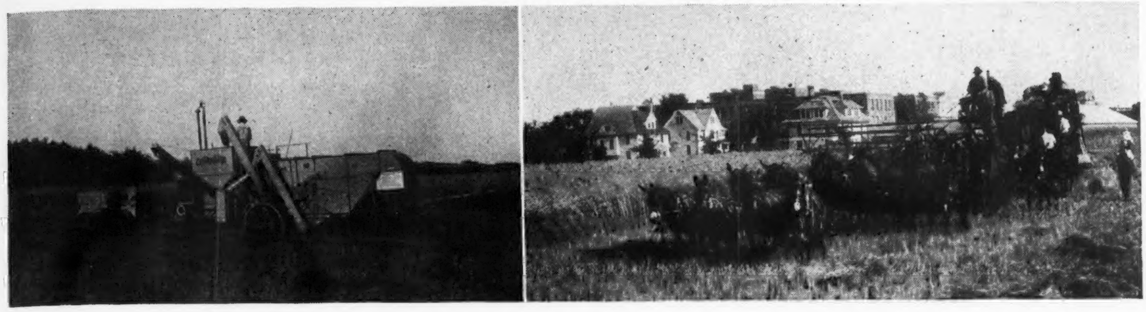
In these respects the extension engineer will find excellent opportunity for cooperating with other subject-matter departments. The roadside stand not only requires knowledge of the consumers' demands but of how to build a suitable stand. The truck and automobile, of course, fall decidedly in the field of the agricultural engineer. All three of the problems of transportation mentioned are closely tied up with highway problems. Whether or not the farm business is profitable is becoming more and more dependent upon whether it is located on a hard-surfaced road and upon the maintenance of dirt and gravel roads.

Even if the general price level of the United States were to go considerably lower than it is at present, prices of farm products go still lower than they are now and labor should cost even more than it now does, there will always be some farmers making good incomes. This means that the standard of living of the American farmer as set by the successful farmer is not going to decline but will unquestionably continue to rise. The extension engineer is therefore going to have an ample opportunity for assisting workers in the field of home economics by giving information on the use, maintenance and repair of better home equipment. This will include educational work on (1) electrical equipment, (2) water supply and sewage disposal for the farm and rural home, (3) domestic refrigeration, (4) repairing and remodeling farm homes, and (5) installation and maintenance of heating systems.

The question of better home equipment brings us to a subject to which reference has been made above, namely, rural electrification.

The advent of the mower and reaper gave to the farmer machinery which not only greatly increased his efficiency as a worker, in a revolutionary way, but put into his hands more complicated machinery than he had hitherto been accustomed to using. The advent of the gas engine again revolutionized agriculture and again the farmer had to learn to use machinery which was much more complicated than anything within his previous experience. And now, for the third time, we are in a new epoch in farm equipment, namely that of using electricity. Here again is something new, but the research men have already

The extension agricultural engineer has the opportunity of making the farm adoption of electric power much more rapid than was its adoption of animal and internal-combustion engine power



Combines in the A.S.A.E. pageant of grain harvesting progress at Ames. A modern combine at the left. At the right, its prototype, a mule-drawn, wood-frame, ground-drive machine, one commonly used in the Pacific Coast states

carried it well out of the experimental stage, and now the extension man finds an opportunity to hasten its general adoption much more rapidly than the previous epoch-making equipment was adopted.

Last but not least, it should not be forgotten that 4H club work offers an excellent opportunity for the extension engineer to deeply plant the seeds of his chosen field into the fertile mind of the coming generation. This work will induce the farm youth to take a more active interest in farm life by teaching them various mechanical skills which are always of value on a farm and elsewhere. Lessons may be offered that will be of value to the boys now and will form a background and a stimulus for further study later, thus tending to establish higher standards of living.

Because of the scarcity of general repair men in the farming communities, it has become necessary for the farmer and his family to be their own mechanics. Every farm boy recognizes the value of a knowledge of certain skills such as saw filing, soldering, rope splicing, harness repairing, tool sharpening, making a rope halter or framing a rafter. We have found that, if a single-cylinder gasoline engine is to be repaired at all, it must usually be done at home as the cost at a garage or machine shop is often prohibitive. Every boy is anxious to acquire a knowledge of the operation, care and adjustment of the gas engine which will apply to the multiple-cylinder engine used in automobiles, trucks, and tractors, as well as to the single-cylinder engine which he is studying.

SUMMARY

I have endeavored to show (1) that the cause of the present agricultural depression is monetary and not general overproduction, (2) that the general price level is low and will probably go lower, (3) that wages are relatively high and probably will continue so, (4) that transportation charges are likely to remain high, (5) that agriculture is an extensive business; its turn-over is relatively slow and it is a biological and a home industry so cannot "shut down" and wait for prices to rise and then start up again as is common in many other types of business.

To meet the situation, farmers must increase their productivity per man-hour, which is another way of saying they must cut their costs of production.

This can be accomplished only by throwing poor land out of cultivation and producing more on the good land with less labor, which can be accomplished by the use of improved machinery, which means a larger farm business in larger fields free from obstructions.

To decrease the cost of transportation means

1. To produce as near as possible to market.
2. To produce for local markets or roadside stands.
3. Delivering products to market by auto or truck whenever practical.

In bringing about this reorganization of American agriculture it will be the function of the extension agricultural engineer to understand the whole picture and to assist the farmers in every way possible to economically save labor. To do this

1. He must familiarize himself with the general economic conditions
2. He must familiarize himself with the plans of such federal agencies as the U. S. Department of Agriculture and the Federal Farm Board
3. He should familiarize himself with the recommendations and plans of other subject-matter departments. In other words, he should study the problem in a large way to see just where he can fit into the large picture by assisting other departments and agencies and never allow himself to ride a hobby.
4. He should study the farmers' problems first hand by surveys, farm visits or other means of direct contact, to determine wherein the science of engineering can be of assistance. If there are insufficient data at hand, he should be ever alert to find the problems requiring further investigation and carry these problems to the research men for solution. He must then write the findings of the research men into popular language and carry the message to the farmers.
5. He must be familiar with good sound economic farm practices. It would be the height of folly to advise the installation of an extensive irrigation system in humid New York, just because it did not rain for two months last year, or to spend time teaching a group of farmers to lay out terraces to control erosion on land which should be reforested. However, the agricultural engineer should understand and be sympathetic with special conditions which would make these practices practicable.
6. He must be familiar with the most up-to-date labor-saving devices, but in advising their use he should be sure that the farm in question is in proper condition to make full economic use of such devices. The man must have ability and the farm business must be sufficiently large to warrant the expenditure. The farm may be one that should be gradually gotten out of production and the farmer may be a man who should be encouraged to move onto another farm of greater possibilities or even out of agriculture entirely. In other words, the problem may be sociological as well as economic or one of engineering.

The extension agricultural engineer must not forget that as an educator he is a salesman. His wares are ideas In addition to good sound economy, engineering skill and ability, sociology and farm practice, he must study the best methods of selling and delivering his wares in a way that will leave in his wake a series of satisfied customers.

CONCLUSION

We are in the midst of a great depression but there have been similar periods before. As in the past, the American farmer had adjusted himself to the problems of the past, so in the future he will adjust himself to the problems that will arise in the future. To assist the farmer in making the adjustments that are continually required of him with a minimum loss of time and money and with the least hardship to himself and his family is then the function of the extension agricultural engineer.

After the Century of the Reaper, the Century of Power[1]

By Cyrus McCormick, Jr.[2]

ANNIVERSARIES such as this are a human habit as old as the race itself. From time immemorial men have halted their advance and looked backward to the great things, great occasions and great men of the past. Usually the chief interest of anniversaries is a matter of sentiment. Their true value lies in the inspiration we can draw from them and apply to the practical tasks and problems that confront our generation and ourselves.

In recent months I have been concerning myself much with the history of the last hundred years of agriculture. Perhaps I should say not "the **last** hundred years," but the **first** hundred years of agriculture. Certainly no organized agriculture existed before 1831. Men had tilled the soil since before the dawn of civilization, toiling and fighting to win a livelihood from a nature whose every attitude seemed hostile.

Is it not curious that man, when he left his primitive, tribal state, proceeded so soon to organize his religion, his government, his home, his warfare, his social and aesthetic amenities—but not his food supply? Often I ask myself why man did not try to develop a science of food production at the same time he was codifying political rights and ethical standards. Possibly the social status of peasant farmers was so low that no one gave them a thought. Agriculture's advance into the realm of solvable problems had to await the invention of the reaper and that upsurge of mechanical and cultural improvement which the reaper began.

On the other hand, it is equally possible that agricultural improvement has been partially due to a coincidental recognition of the fact that the farm problem is human as well as economic. Both sociology and economics are products of the nineteenth century. All industry was once considered without relation to humanity. But today it is natural to conceive of it as a great field of useful endeavor in which capital and labor, producer and consumer, thinker and doer, all collaborate for the common good. Agriculture also is no longer theoretically isolated from the human problem of farm men and women; and it has attracted to itself a body of new thought. Machinery and science have gone far toward turning it from haphazard effort to exact method and conclusion; and yet the human portion of the equation is still unsolved.

My own recent researches into the history of what I have called the "Century of the Reaper" have led me to a stimulating conclusion. I believe that my grandfather is to be esteemed not so much because of the invention of the reaper as because he first of all men unlocked the door to modern agriculture. In sketching the story of the reaper and what has followed it, I have written a book to indicate a chain of successive improvements, each one growing out of or alongside another. Obviously, John Deere's epochal plow of 1837 was not a descendant of McCormick's 1831 reaper; but, also obviously, it was a product of the awakening to the possibilities of mechanical agriculture stirred by the invention of the reaper. As the century raced along, this energy was stimulated and broadened. It produced the harvester and the binder, the cultivator and the lister, and, most recently, the harvester-thresher and the tractor. It gave to agriculture the first tools of mechanized farming and now it has provided the multiform artifacts which are the sinews of power farming.

That, in brief, is the story of the mechanical half of the Century of the Reaper. It has seen the growth of the use of machinery on the farm and also of an industry wide enough and fine enough to service the equipment which modern agriculture has learned to use to such advantage. It has turned the farmer from a toiling serf into a productive worker commanding machinery with his brain. But that is not the whole of the story. Science is broader than mechanics and the stimulated thought concentrated on farm problems by the invention of the reaper has overleaped the boundaries of machine equipment.

How can one seek to study present-day agriculture without doing honor to Burbank, wizard of better seeds; to Hilgard, first among soil experts of our time; and to Knapp, who contributed so worthily to the organizing of the social values of farm life? Surely this anniversary year must pay tribute to Beardshear, pioneer of agricultural education; and to "Tama Jim" Wilson, father of agricultural administration. Historians have not yet accorded these scientists the place in farm betterment which the future will accord. They were dedicated specialists as were the inventors, men who worked with their minds for agriculture.

It is to these two elements of the Century of the Reaper, to its mechanistic and scientific impulses, that the American Society of Agricultural Engineers has rightly devoted the major part of its attention. True to the traditions of the engineering fraternity, you have marched with the development of agriculture—and yet your profession is itself as young as modern agriculture. Perhaps, even, there were no agricultural engineers, as we understand the definition, until well into the twentieth century. But long before the formation of the A.S.A.E. engineering skill was devoted to agriculture.

Recall any great name among the men who helped found the agricultural implement industry: they were all engineers. Not by training, it is true, any more than they had been trained as inventors or manufacturers or salesmen. A man does not inherit genius nor can he acquire it by education. He is an inventor or an explorer or an artist or a statesman because there has been added to his consciousness at birth some faculty which makes him a leader rather than an average man. Thus it was with McCormick, who made a great idea practical and then, in and of himself, produced a business system to accompany his invention. So also it was with Deere and Oliver, with the brothers Marsh, with Whitely and with the many others who fought and rose and made the last century famous for their achievements. Inventors all—and all captains of the industry.

Inventions and patents—these were the by-words of agricultural engineering in the old days. Who but the head of the business was wise enough to judge the niceties of a cutter bar or the shape of a moldboard or the intricacies of canvas speeds? Where should agriculture seek its leaders except among the men who were able to master these subjects? There were mechanics who carved out patterns; and there came to be expert constructors who learned to carry out the ideas of their chiefs. But for nearly half the Century of the Reaper the head of the business was his own engineer. A man had to be versatile to win in the savage competitive strife of the days when modern agriculture was young!

As the reaper began to outgrow its youth, the problem of mechanistic farming became too broad for the solitary minds of the early leaders of the implement industry. Follow the harvest as they would, they could no longer alone keep pace with the demand for improved machinery. Agri-

[1]An address before the 25th annual meeting of the American Society of Agriculture Engineers, at Ames, Iowa, June 1931.

[2]Vice-president, International Harvester Company.

culture was moving as fast as the whirlwind of thought released by the invention of the reaper. But demand always discovers its own supply; so, with the need for the grain binder, there appeared other inventors, men such as Withington and Appleby, who approached the problem from the standpoint of the specialist. They were experimentalists, unconcerned with the more usual phases of the industry, empirical engineers who attacked their subject because the flame of genius burned unquenchable within them.

The stage of modern engineering was not set until after "the good old days" of the fighting eighteen-nineties when warring implement salesmen stormed through the land, blithely slaughtering one anothers' reputations with the weapon of the "talking point." Something new, they clamored, we must have something new—anything novel provided only that it attracts attention. Thus an army of unnamed implement designers set to work in the front line harvest trenches; and many a startling innovation certified to revolutionize farming was worked out by lamplight in a country blacksmith shop. The industry progressed because its captains and its legions were fighters. Much of the work was doubtless unscientific simply because there was no time for a second thought, no opportunity for a drawing board, no respite when a striving competitor could ask himself if what he had roughed out was sound engineering. Yet practice has ever preceded theory and the precedent of success lay with those who accomplished.

When the twentieth century began the whole implement industry lay exhausted by the strain of its own methods. The harvester men were spent with their struggles, the plow fraternity was breathless with the vain task of following a mad example. Consolidation saved the companies from commercial extinction. It also gave the third generation of leaders time to study their situation and see what was wrong. A first fruit was the birth of organized agricultural implement engineering.

The results accruing from this desirable step have been great. Within thirty years the grain binder, the mower, the rake and the corn binder; the plow, the cultivator and the lister; the clumsy threshing machine and its snorting engine were all rebuilt and refined. The tractor and the motor truck were introduced. A legion of new implements suitable for modern farm methods was developed and made practical. The instruments of power farming were pioneered. All this happened because some few specialists were given time and place and means to work out the answers to the insatiable demand for better farm equipment. Farm machinery and farming have prospered because our industry was wise enough and able enough to recognize and organize that unquenchable genius which men call invention.

Let me repeat that the long step ahead which our generation has taken has been due to what our hurried, individualistic, untrained, fearless ancestors accomplished. The basic shape of yesterday's moldboard turns the soil today; the seven principles of the reaper of 1831 are inherent in the harvester-thresher of 1931. Are those facts not eloquent enough of the worth of the past? Remember that today's farmer, aided by machinery, is a hundredfold as efficient as the farmer of yore. They built well, those intellectual giants who founded modern agriculture a hundred years ago.

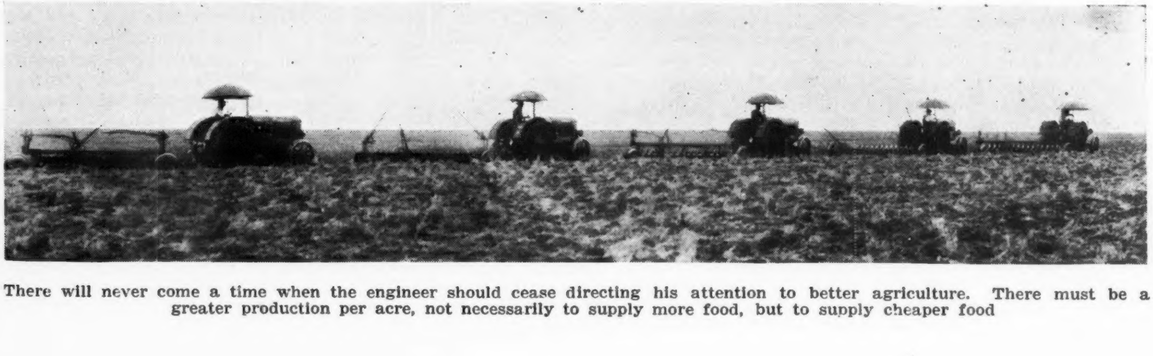
The mechanical improvements they began have been accompanied by a less obvious but equally vital series of changes. Other men on this program are better equipped than am I to rehearse the tremendous advancement science has brought to farming in an ordered knowledge of seeds and soils. Machinery led the way but it could not have succeeded as it has without the scientist in his laboratory, the teacher in the agricultural college, and the dreamer building in his mind an anticipation of the future. Their work has been telling. It may be fair now to suggest that neither the producer of farming mechanisms nor the producer of farming ideas can hope to see his work live without counting on the youth of the farm community as we see it enlisted now under the banner of 4H club devotion.

Those boys and girls have only a fading tradition of the struggles of their pioneering ancestors who braved the wilderness to found the Empire of the West. Possibly none of them has ridden a one-cylinder tractor. Their fathers' generation had never used the reaper, so why should they concern themselves with the history of the Century of the Reaper? Youth looks ahead, not back. What will they say if we do not all of us continue to improve as our fathers did, and help them found a second century, the "century of power"?

Power is the by-word of our times. Power in the factory and on the farm, in the home and in our methods of relaxation. Our fathers produced for us the bases of our supercontrol; we have applied their systems to new devices. Our might is unlimited, we are the masters of things material. We can produce—we can almost create.

Our generation spans the last years of the first century of mechanized farming and the early years of the next. Behind is a record of agricultural achievement; and yet the final solution of all farm problems is not in sight. Why should it be? Advancing standards are constantly disclosing new ideals. Men reach the horizon of known events only to discover untravelled leagues ahead. New times uncover new needs and demand new progress. Are we willing to explore as did those voyagers in their covered wagons, those dreamers who visioned two grain stalks growing where one grew before, those inventors in their country blacksmith shops? Can we learn to serve our generation as they served theirs?

The field ahead is broad. At its margins are the polar ice caps between which stretch the cultivated acres of the Occident and Orient. At the bottom of its scale is the man with the hoe; at the top is the man with the electric push-button. If we set aside the swamps and the deserts for development by the population of the future, there is usable land aplenty for us to deal with. Also, we will probably not wish to ascend or descend the complete reach of the human scale. We want no mere peasantry struggling with its naked hands to give us bread. Neither do we wish to seek unattainable abstractions or to control life with a wand, for that would eliminate the sound human element of hard work. Productive effort is good. Rather, let us deal with the world as it is, a world that



There will never come a time when the engineer should cease directing his attention to better agriculture. There must be a greater production per acre, not necessarily to supply more food, but to supply cheaper food

is learning to call heavy or purposeless labor inhuman, a world in which man rules mindless mechanism by his brain and yet maintains his thought fresh and strong by his activity.

It seems to me that former methods of approach to the problem of agriculture are insufficient for exploration into this second hundred years. We have provided the farmer with such machinery as he has needed and with such science as he could learn to use. Perhaps now we must have recourse to another ally whose power must be added to the continuing pressure of machinery and science—perhaps we must now add to the agricultural program a study of practical human values.

The dictionary defines the science of human values, or sociology as it is called, as "the science that treats of the origin and history of human society and social phenomena, the progress of civilization, and the laws controlling human intercourse." Those, surely, are matters which touch agriculture! "Origin and history"—we know what those have been: the peasant became a citizen. "Society and social phenomena" — the rural portion of our people and their needs. "Progress" — what would today's civilization be but for the progress of the farmer? "Human intercourse" — who in this day is foolish enough to say that the distress or the prosperity of a nation or an agricultural community does not affect its neighbor? Think it over: It might be well for the A.S.A.E. to found a section on human affairs.

There is still plenty to do scientifically and mechanically; but there are also such questions as these to answer:

Why is it that the majority of students in our state colleges, so many of them with a farm or other rural background, do not elect agriculture as their study? The law, medicine, the industries are supplied or oversupplied with talent and with candidates for place; and, on the contrary, the fact of the existence of such societies as this indicates that there is much room in the world for agricultural engineers. Manufacturers and salesmen can be made, but the inventors of the future must be born with genius in them which will flower as it may be directed. Where, except in the 4H clubs, is the future farmer who will apply proved theories and developed machinery to the solution of immediate problems? Why does farming seem so little attractive as a future career to sons of farmer fathers?

The answer lies, I think, within the sphere of economics. Farm boys and girls have for ten years been hearing about the unprosperity of agriculture. A little while ago things seemed to be changing for the better; but when the period of world depression set in rural distress became acute again. What profit is there, they have learned to ask, in devoting one's life to a hopeless cause?

What are the facts? Is agriculture really so badly off? Let us admit that business is in distress all over the world and that there is no sign of improvement. Let us agree that the price of farm produce is relatively lower than the prices of other commodities. But agriculture is not bankrupt, nor can it be until men cease to eat.

Banks have failed wherever they were choked with mortgages scaled to unreal prices. Industrial organizations have fallen when their production has been geared to a purchasing power based on capital rather than income. Speculation has collapsed as it always does, and those who sought to gain without producing have been or are being swept into the discard. And yet agriculture, the depressed step-relative of boards of trade and stock exchanges (so it is said), is the strongest, most resistant industry in our land.

It is a surprising and significant fact that of all the farm land in the United States, half of the cultivated acreage and half of the farms are unmortgaged. There is distress among wheat raisers, true — but wheat is a symbol only: Its value is less than 8 per cent of cash farm income. Cotton, dairy products, livestock and poultry products — all exceed it. Believe it or not, there is better basic security in farm land than in the business structure of the nation.

Half of the cultivated farm land of the country, I repeat, is free from encumbrance. Let us take courage from that fact. The owners of these acres may seem impoverished if one looks at their income account alone, but their capital is secure. They deserve extended credits and are getting them. They hear of and feel the depression all around them and are disturbed and discontent; and yet their sure salvation lies within themselves if they are but aided by machinery, by science and by society's understanding of their human equation.

We stand at the threshold of the second century of modern agriculture. A new and different appreciation of agriculture is needed. There can be no new system of banking to suit the needs of the future without an insight into the social value of agriculture. There can be no new system of marketing to carry on where other plans have failed without correct evaluation of the farmer's aspirations as well as his functions. Agriculture needs appreciation more than it needs assistance.

Certain things must be done: Take the farmers' problems out of the field of party politics and into the field of understood science. Let the strength of individual and cooperative initiative rather than subsidy supply agriculture with its future sinews. Eliminate the speculator who too often has battened on agriculture without himself contributing one single effort to its cause. Prove to bankers how they may prosper their own interests by coming to the aid of an agriculture which offers the security of the most basic of all industries rather than speculative values as a reward. Add the accumulated store of business wisdom to the business methods of agriculture. Do these things and we will begin to make the Century of Power vitally constructive enough to win the allegiance of the new generation.

Of course there will never come a time when the engineer should cease directing his attention to better agriculture. The Century of Power clamors for an understanding of soil values just as the Century of the Reaper did. There must be a greater production per acre, not necessarily to supply more food but to supply cheaper food. There must be a finer knowledge of seeds and plants to draw more return out of each. Find an adequate use for straw, for example, and you will have doubled the returns of the grain farmer.

Do not tamper with economic law. It is inexorable. A farmer cannot expect to control the price of his product, if he is unable or unwilling to control the volume of the supply. He cannot expect the urban factory worker to buy bread if that worker's wages fail. Nor should agriculture expect the scientist or the machinery producer to provide him with such equipment that, by pushing a button, he can feed his cow or milk her — get something without effort: for nothing, as it were. Science and machinery help, but they are not a substitute for those hardy mental processes which, ruling the equipment and methods of the future, are the coherent expression of economic law.

Before its close the Century of Power will see in existence useful, productive mechanisms which are undreamed of at present. Internal combustion is but a step in the ultimate direction, and either high-compression engines or a better utilization of fuels is a further step. The tractor itself is changing and will change still more radically as engineers discover how to adapt the all-purpose power unit to existing or new tasks. No time-honored process is sacred if a better one can be introduced. No human product can ever be the ultimate until humanity achieves infinity, or necessity ceases to exist.

What holds a better hope for the years of the Century of Power than that the farm boys and girls find in the problem of the farm a challenge so unmistakable that they leap to face it? The equation of agriculture is before us awaiting study, selection and solution. Our ancestors began in 1831 to supply the answer. Can we be satisfied merely to profit by their efforts, or shall we be spurred by their example to a new mastery over new problems? Agriculture awaits our answer.

Electricity and the Agriculture of the Next Ten Years[1]

By E. A. White[2]

IT IS a distinct pleasure and an unusual honor to have the opportunity of addressing my fellow workers upon this occasion—the twenty-fifth anniversary of the founding of the American Society of Agricultural Engineers. Proud as I am of the achievements of this group of men, it might not be entirely fitting for me, who have been one of you from the beginning, to review our successes and failures. Anyhow, I take little satisfaction in attempting to write history. Our record for these twenty-five years is made. Frankly, it matters little what we may say about it. Whether it is good, bad, or just passable will be evident when the time comes for evaluating the agriculture which this generation passes on to posterity. I believe this to be a fair measuring stick. We are expected to produce results—results which will show in the lives and practices of those who till the soil.

In order to discuss the place which electricity may occupy in the agriculture of ten years hence, it is first necessary to build a perspective, or at least a partial perspective, of that agriculture. If electricity were the dominant force directing the path of agriculture, we would start at the other end and, by deduction, arrive at our picture for the future. Such, however, is not the case. There are many forces shaping the destiny of American agriculture, and it is still an open question as to where electricity will rank on the list. Therefore, electricity will be considered simply as one among many.

Frankly, the only justification for choosing such a subject is the hope that it may stimulate thought and provoke discussion. It offers ample opportunity for differences of opinion. From my own standpoint, attempting the role of a prophet is most unsatisfactory. History shows that most prophets popular in their own day and generation have been wrong, and that most of those who have been right have been unpopular. In addition to this I do not know what agriculture will be ten years hence, and I have a deep-seated Scotch suspicion of any one else who claims to possess such knowledge.

However, one thing appears to be certain: Agricultural practice will be different ten years hence from what it is today. While as a covering for the great sphere of truth I am willing to admit that "there is nothing new under the sun," yet within this generalization, in respect to those things which influence the economic and physical well-being of man, we are subject to nothing else but change. Economic equilibrium is a most unstable condition and someone is always introducing a catalizer which compels a rearrangement of the molecules. Apparently, as has been so often expressed, in the affairs of men there is only one sure thing, and that is change. However this thought may disconcert us in certain directions, we can at least have the satisfaction of looking forward to a new agriculture ten years hence. The engineer, especially the agricultural engineer, may well revel in this thought, for to him it should be the door which opens to opportunity.

We may expect the percentage of our total population engaged in agriculture to show a further decline. The primary factor influencing this change is the total horsepower in prime movers and horsepower-hours used on our farms. This has increased, and the end is not yet. We can logically expect more horsepower per agricultural worker ten years hence than is the case today. Yet, due to our modern transportation system, city rents and taxes, the number of people living in the country or suburbs may increase. This particular phase of national development will probably not be of especial importance to agriculture, but there are evidences of another movement which may have a profound bearing upon the situation. With all farm land reduced in price, much marginal land to be secured at an extermely low total figure, and industrial competition in our cities becoming more intense, there is already a "back-to-the-farm" movement under way. It is, of course, problematical how long this will continue. Perhaps it depends more upon urban economic conditions than any other single factor.

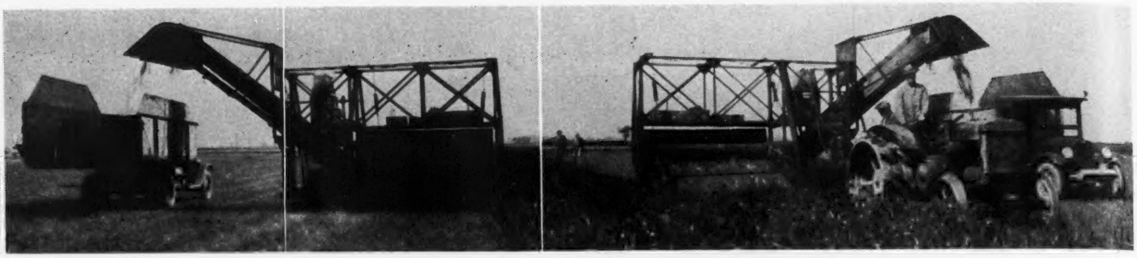
Among others this brings to agriculture a class of people barely able to eke out an existence. As individuals they produce but little above the bare necessities for food, clothing and shelter. Yet as a class the products they market enter into competition with those produced by farmers maintaining what we are pleased to call the "American living standard." It is a beginning of peasantry in our agriculture and furnishes a challenge to the engineer. Perhaps the best solution is to develop a system whereby these people will be afforded an opportunity to work under the direction of management, and by this means raise their production to a level sufficient to maintain this higher standard of living.

Electricity is a new force in agriculture which is making for fundamental changes in its organization and methods as well as immediate and superficial changes

This situation leads us directly into the much discussed question of the corporation farm. Let us recognize at the outset two facts with reference to the corporation farm: First, the idea is not new, and, second, mere size is not a guarantee of economic success. There have been large wheat farms, large cotton plantations, large sugar plantations, large general farms, in this and other countries for years. Some of them have been successful and some have not. The recent experiences of the sugar plantations, with managers, engineers, large acreages, railroads, power plants, factories, and stores furnish conclusive proof that managerial ability, engineering talent, large output, a high degree of mechanization, and all that is supposed to go with corporation farming, will not insure economic success. At the same time there have been plenty of family farms facing just as much trouble. Then we can find both corporation and family farms which have been successful.

[1]An address before the 25th annual meeting of the American Society of Agricultural Engineers, at Ames, Iowa, June 1931.

[2]Director, Committee on the Relation of Electricity to Agriculture. Charter A.S.A.E.



Forage drying is just on the horizon. There are sound reasons for believing that ten years hence the artificial drying of forage crops will be an established agricultural practice

It is very easy in discussing this question to get the cart before the horse. It is not the system which is important, but the man. A man of ability and vision as the manager of an agricultural enterprise will evolve a system which works whether the unit is large enough to employ the services of a hundred men and therefore be classed as a corporation, or whether it is small enough to be classed as a family farm. On the other hand, poor management fails no matter what system is used and what the size of the undertaking. The primary question is not systems but men.

Much could be said on this subject; in fact, much will be said. My own ideas are that ten years hence the family farm will still be the dominant force in American agriculture, because there are enough men of ability who prefer this form of life to insure such a result. Yes, there will be changes in the average size of such farms, changes in crops, changes in systems of farming, but, after all, the man of ability on the family-size farm can produce with such a small overhead that he will defy competition for many years to come. Roughly, we might consider one-third of our present farmers as falling within this classification. After all these men are the backbone of our agricultural system and promise to so continue for the period of time under discussion.

Then there is a group of people attempting to farm who find the present situation too complicated. Perhaps another one-third of our present farmers are definitely enrolled in this classification. Certainly these people should be better off working under intelligent direction. Some form of managerial supervision or corporation farming enterprise will fill a real need here, but it is a question as to whether or not a manager would either seek or welcome these men as the labor background with which to work. Thus human welfare comes into direct conflict with the engineer's insistence on efficiency. As engineers we extol efficiency in season and out of season. We demand efficient labor, but we have not told the world what to do with the human beings weeded out by this exacting system. Perhaps it would be desirable for us to give as much attention to human as to agricultural wastes. Yet I doubt if any system of management or corporation farming will offer a permanent haven for this class of labor. If this conclusion is correct there will be another large addition to the class drifting toward peasantry. Here again is a challenge for the engineer. Can anything be done for the farmer with limited ability? I have no answer for this question.

No matter what the influence of corporation farming may be on the problem just discussed, this particular form of agricultural management (the corporation farm) promises to increase in importance. It will probably continue to take two general forms. The first will be described as supervised operation. In this system there is generally found the family size of farm and it is so operated. The systems of farming followed, crops to be grown, seed to be used, time of doing various operations, financing, etc., are, to a greater or less degree, dictated by a manager. This affords the man who is a good operator but deficient in certain other attributes, such, for example, as financial ability, a real opportunity. It has been tried by banks, insurance companies, private corporations, and individual land owners with varying degrees of success. However, due to the large amount of land now owned or controlled by financial institutions, we can expect to see a marked increase in this form of corporation farming during the coming ten years. It has marked possibilities. Technical and financial service will be available. The farmer who is a good operator will have an opportunity to concentrate upon what he knows best and what he likes to do, unhampered by technical problems for which he has little inclination. The overhead expenses will be reduced to a minimum. We may even find a number of family-size farms banded together for the purpose of taking advantage of such a service as this. It should be especially attractive for what I have classified as the middle one-third of our farmers.

What might be called the corporation farm proper, that is, where one company owns and operates a large acreage of land, promises to receive further testing. Its success depends primarily upon having available the services of a man with unusual ability and vision as well as access to substantial financial support. A few will succeed. Many more will fail. Out of the wreckage there will emerge a small but well-selected group of men able to manage large-scale agricultural operations. In fact, this group is already beginning to emerge. However, ten years hence is too soon for this type of farm operation to wield the influence upon agriculture which will be exerted, first, by the independent land owner, and second, by the managerial supervisory system. Truly this phase of agricultural development appears most inviting. One thing appears to be certain; the control of land will ultimately gravitate into the hands of those able and willing to operate it.

What may ultimately prove to be one of the most significant agricultural developments of our time is the beginning of what may be called a "permanent farm-mindedness" on the part of our farm population. In the past it appears that a large proportion of our farm people have been both mentally and physically on the move. In the pioneer days it was west, ever west to new lands. The vanguard of this procession often moved three or four times turning their partially developed holdings over to other movers who followed from the East. Later it was the movement from farm to town. The idea was to save, acquire a competence, move to modern conveniences for the wife, education for the children, and horseshoe pitching, croquet or other forms of diversion for the farmer. By this means the rural districts were stripped of surplus capital, mature judgment, and operating experience. Furthermore, it was no exceptional experience for the man who moved away from the farm to give it no further attention than to collect money due or find a new tenant.

Fortunately, there are evidences that this situation is changing. For various reasons it being recognized that the owner of land has a responsibility for its operation. An increasing number of people who live on the farm are coming to look upon it as a place of permanent abode. Interest is not centered upon moving but upon improving, making the farm a desirable place to live as well as to make money. Such a frame of mind leads to better homes, better roads, better schools, in short, the building of a

rural community. There is every reason to believe that the next ten years will see a further substantial development in this direction.

All of this means that we are going from a generation of land holders to a generation of land operators. While there were notable exceptions, as a rule profit has come from the increment in the selling price of land. The successful farmer was one who was most dexterous in keeping the expenses down, mining the fertility, selling out at a high price, getting the cash, and moving away. The profits in farming during the next ten years will come from operating as contrasted to holding land. The operators' outlook, methods, and results are entirely different from those of the holders. The results in this direction will be of signal benefit to agriculture and therefore the nation. We may learn, although it is doubtful, that high-priced land is a good thing to sell and undesirable property to own.

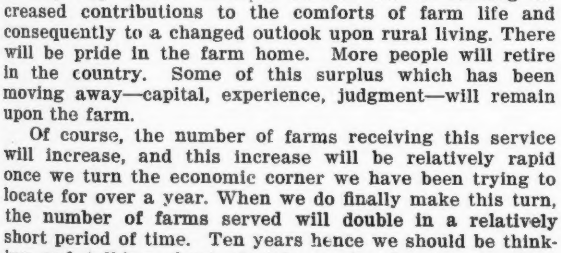
The place which electricity will occupy in the agriculture of 1941 is a most interesting speculation. Naturally, I am enthusiastic over the outlook—more so than was the case eight years ago. For this reason you may find a "factor of safety" useful in evaluating this part of the discussion. However, do not make this factor too large for it is the habit of electricity to put its own prophets to shame. It generally outruns their predictions both as to the amount of energy used and the variety of uses to which it is put.

Curves showing the total amount of electricity used in agriculture and the number of farms served are still pointing upward. We may well ponder over the significance of these facts for among other things it undoubtedly indicates that the farmer and his family find this service of value. It is probable that ten years hence the farm without electric service will be looked upon as lacking one of the essentials for economic production and desirable living standards. Already prospective purchasers of farms put the question with reference to electric service near the head of the list.

There is no other one source of energy which offers so much to the farm home as electricity. This fact will be taken advantage of in full measure. Ten years hence there will be many more farm homes than is the case today equipped with just as many modern conveniences as any city home. Electric service will be making increased contributions to the comforts of farm life and consequently to a changed outlook upon rural living. There will be pride in the farm home. More people will retire in the country. Some of this surplus which has been moving away—capital, experience, judgment—will remain upon the farm.

Of course, the number of farms receiving this service will increase, and this increase will be relatively rapid once we turn the economic corner we have been trying to locate for over a year. When we do finally make this turn, the number of farms served will double in a relatively short period of time. Ten years hence we should be thinking and talking about electric service for three million farms. This appears to be one of the big agricultural developments just ahead of us.

The adaptability of electricity to stationary operations has been amply demonstrated. In the future it will furnish an increasing percentage of the energy required for such work. This adaptability will hasten certain developments. For example, the increased use of irrigation in humid regions, especially for fruits, vegetables, and pastures, promises to be materially accelerated by the introduction of electric service. In this connection it offers the family-size farm a most usable form of energy and therefore gives this farmer another means for competing with larger units. It will reduce hard labor and increase the output per worker.



Ten years hence electric service will be making increased contributions to the comforts of farm life, and consequently to a changed outlook upon rural living

One would be bold indeed to say that electricity will never be used as a source of energy for field operations. In fact, it is so used today to a limited extent. When experiences in this field are analyzed, it appears that some new developments, either in the transmission of energy or the storage battery, will be necessary before the electric motor becomes a serious competitor of the internal-combustion engine. However, the problem is being aggressively attacked, and the next ten years may bring startling results.

Due to the still unrealized possibilities for cooking, refrigeration, water heating, irrigation in humid regions, hotbed and soil heating, ultra-violet light, not to mention numerous other well-known and proved uses, together with such developments as forage drying and fiber processing appearing on the horizon, and unknown uses certain to be developed by the inventor, engineer, and chemist, we can look forward to a remarkable increase in the total amount of electrical energy used in agriculture. Just where ten years will bring us in this development it is difficult to say, but ultimately I look for an average energy consumption per farm of between 500 and 1000 kilowatt-hours per month.

Foreign agricultural competition promises to increase. Information spreads over the world relatively quickly today. Great areas of fertile land have been opened to cultivation. No matter what the ultimate relation may be between acres of fertile land and world population the coming ten years promise increased foreign encroachment upon world markets which for many years have been dominated by products from farms of the United States. There is promise that in some measure the experiences of our eastern and European agriculture, following the opening up of the Mississippi Valley, will be repeated. Lower priced lands, in many cases with a liberal supply of virgin fertility, make it difficult for us to compete in the markets of the world for certain raw products, due to our high capitalization and high standard of living. In fact, authorities whose opinions warrant respect are now telling us that the farmers of the United States must withdraw from world markets on certain commodities. Here is another challenge. Are we to admit that our system of agricultural civilization is unable to compete with other systems? If so, what does our boasted efficiency amount to? I doubt if the engineer will subscribe to such a philosophy.

Let us look just a moment to the logical outcome of such a scheme of things. First we withdraw on one product and then another. Finally, except for the advantages of soil and climate as affecting the production of a few products and probably not even these, the farmer is reduced to our domestic market. Tariff walls maintain food prices at a high level. Living expenses go up. The people purchasing food outnumber the producers four, five or perhaps ten to one. What will happen? I seriously doubt if any tariff wall will stand against this combination of circumstances. The last state will be worse than the first. If, however, the agricultural-production-for-home-consumption-only theory should prevail it would probably just be getting under full headway ten years hence, and might bring with it temporary success. No matter which course may ultimately be followed, the farmer is confronted with a choice, viz: reduce production costs to such a level as to meet world competition, or reduce production to a domestic basis and depend upon the efficiency of a tariff wall. If I know the farmers of these United States, they will hesitate a long time before voluntarily surrendering the

world markets to the producers of other agricultural regions.

On top of this international competition there is an internal competition between regions within our own country which promises to sharpen the wits and reduce the costs of production and distribution. No matter what may be done through cooperation it appears that this development will run its course until it is determined what regions can most economically produce and market certain products. Agriculture is highly competitive. The rearrangement of production schedules between our great farming regions will be an interesting study during the next ten years. We will see progress made in the confining of agricultural enterprises to regions especially adapted to their requirements. From the standpoint of the individual farmer the trend promises to be away from diversification and towards specialization. If such is the case, another well-inflated bubble will burst.

Developments give us no peace. The engineer, the inventor, and the chemist are constantly coming forward with something different which more or less completely upsets the established order. The results of the efforts of these groups of restless mortals often show in most unexpected directions. No established practice is sacred to their piercing gaze. Things which are pronounced "impossible" apparently have an irresistible attraction for these men. From this standpoint the amount of hand labor in the present methods of producing cotton is heresy to the engineer. The next ten years should result in the successful fruition of the efforts to produce a cotton chopper and cotton picker. The changes to be brought about by such a development have been amply discussed.

However, there is another possibility which has received scant attention. Cotton is not the only plant from which usable fiber can be obtained. There are many plants such as flax, hemp, ramie, which have high quality fiber in their stems. The problem has been to get this fiber out of the stem without destroying it. Furthermore, many of these plants yield a high quality cellulose which is becoming of increasing importance as an article of commerce. There is every reason to believe that the problem of retting these fibrous plants will be successfully solved. In fact, such a machine has already been developed. It remains to be proved commercially. Should this development materialize, a whole list of new crops will become of commercial importance, competing with cotton for the fiber market and timber for the cellulose market.

Such a development would bring further regional competition for it would break the monoply of the South on fiber production. Perhaps by the time we get our cotton picker developed we will not need it.

Then there is another possibility. Maybe the chemist will manufacture our fiber in a factory. In this case there would be a demand from agriculture for the raw products, probably chiefly cellulose. No matter what the course of developments may be, it is my guess that ten years hence cotton will have to face much stiffer competition than is the case today. We are going to find ways and means of utilizing our other fiber-producing plants.

Forage drying is just on the horizon. Hay is one of the few important articles of commerce requiring drying in connection with which the artificial process is now used to a greater or less extent. There are sound reasons for believing that ten years hence the artificial drying of forage crops will be an established agricultural practice. This development opens up a large field for speculation regarding its effects upon farm cropping systems. It is already reported that on two large dairy farms the silos, or at least part of them, will this year be filled with dried corn. It is also reported that on another dairy farm the manure is put through the hay drier. It will mean new importance for plants of little commercial importance today, more grass crops, less cultivated crops, less work of the land, more work on the crops. This is one of the significant possible developments which promises to give the livestock industry as at present constituted a new lease on life.

The chemist has not been content to confine his efforts to the fiber field. He has wandered far and wide in fields which have to do with our diet. There is a feeling that the human race will tolerate the pranks of the chemist with things which it wears, but rebel when he begins to concoct synthetic dishes for its palate. Maybe this feeling is correct, but the eating of yeast by the human family causes me to doubt it. Just another example of the same idea:. It is not so many years ago that bran was recognized as a first-rate cow feed. It still is, but in addition today it is sold in fancy packages over the counters of our grocery stores.

This chemist appears to be bound and determined to overthrow the cow and the hog as producers of fat for human consumption. There are well-informed chemists who tell us the human race can be fed cheaper and just as well from vegetable fats as compared to the present animal fats. We are all familiar with the vitamin argument as affecting this situation. However, when we look at recent progress in the science of nutrition my guess is that ultimately the chemist will succeed. As engineers we might well question the efficiency of the cow as a producer of human food. Look at all the work required. Why should the human race be compelled to feed, clean, and milk cows twice a day, three hundred and sixty-five days per year, in order to obtain fats, minerals and vitamins? Now, with increased competition for the cow, we have started milking her three times a day, thereby affording still less peace for both man and beast. The engineer is interested in a better way and therefore will join hands with the chemist in the production and utilization of vegetable fats. There is every reason to believe that ten years hence butter will be facing much more intense competition than is the case today, while perhaps the squeal of the pig, which, according to latest reports, was still escaping the packer, may be as valuable as its lard.

When the situation is analyzed we find the animal chiefly entrenched today behind its ability to produce proteins for human consumption. This fact disturbs the chemist not at all. For example, he has been investigating the soy bean as a source of human food and finds it rich in protein, oils, minerals, and vitamins. It is discovered that the protein of this bean is peculiarly adapted for human food and highly digestible. Some chemists look upon it as a base material for making a substitute for milk, pointing out that such a process would be much more efficient than the cow. Others see the soy bean steak as a possibility. True, we do not like the flavor of this soy bean. Very well, the chemist will extract the substance which is responsible for this disagreeable taste and introduce any flavor we may desire.

The agricultural practices which would follow such a train of developments are, of course, tremendous. Crops would be developed especially for the fats, proteins, and other food elements. Why, these chemists may yet have us eating alfalfa! Well, we can only promise that the agricultural engineer will keep pace with them in doing his part toward making human food better, plentiful, and less costly. We hold no brief for the cow or the hog, the cotton plant or vegetable oils, but we are fundamentally interested in seeing the human race properly fed, clothed, and housed at a low overall cost.

If there were time, it could be pointed out that we now import large quantities of both fats and fibers for commercial purposes. It is possible these new developments may enable our farmers to obtain a large part of these markets.

The foregoing by no means exhausts the factors or forces which are influencing the future path of agriculture. Nothing has been said about (1) the battle between the horse and the tractor; (2) transportation development; (3) the living of the farmer and his family in villages; (4) the competition which smaller animals, such as the rabbit, the hen, ducks, and geese are furnishing the beef cow and the sheep; (5) manufactured weather for our homes; (6) farm organizations, especially those relating

to buying and selling of products or service; (7) the gradual depletion of our store of fertility; (8) marginal farm lands; (9) the growing of plants from which rubber will be obtained; (10) the tenant system of farming; (11) utilizing wastes from present crops; (12) taxes; (13) educational facilities, etc.

There is plenty of material available here for another paper or papers as long as this one. Any one of the foregoing subjects may be just as important in shaping agricultural development as those selected for this discussion. Perhaps something not even mentioned will yield a greater influence than the factors listed.

It is hoped and believed that ten years hence the farmer will take more pride in agriculture as an industry, vocation or profession. We will hear less about the number of men born on the farm whose names are listed in "Who's Who." Why, from the standpoint of agriculture, should we make so much fuss over the men who have left this field? It reminds me of the humorous statement attributed to Bill Nye, viz: "Many great men come from Indiana, and the greater they are, the faster they come." No, of far greater importance to agriculture are these master farmer and homemaker movements, and other distinguished awards for service or achievement. If necessary, let us build a "Who's Who" for farmers.

There is another fallacious line of reasoning which will not be handicapping agriculture as much in 1940 as it has been in recent years. It leads to the conclusion that the farmer is not able to look after his own business; that somehow or other, certainly by some means foreign to human experience, business, industry, a federal board or an agricultural experiment station is going to be the great Moses to point the way to agriculture; that if the farmer ever enjoys prosperity it will be due to the brain effort of someone outside of the agricultural field. Away with such reasoning! This wish we have heard expressed so often of late—that business or industry must save the farmer—should be classed for exactly what it is—pure, unadulterated bunk. Business is no more going to save agriculture when it is in trouble than agriculture is going to come forward and save business when it meets economic distress. What we want in this country is an independent, ambitious farmer able to look after his own business. Ten years hence we hope for a mental attitude on the part of the farmers which makes for pride in agriculture, independence in thought and action.

To me, the agriculture of the next ten, yes, twenty-five years has a most interesting outlook. It is interesting because of the multitude of possibilities and the lack of definite information as to just what is going to happen. It is a situation in which the agricultural engineer should grow and develop; one where the economic fortunes of the individual farmer may ebb and flow with great rapidity; one which may greatly influence the character and type of our agriculture for years to come, an opportunity to create something different even though "there is nothing new under the sun."

There probably will be a still smaller percentage of our population living on farms than is the case today. The industry will be further mechanized. New crops will become of commercial importance. Competition between great producing regions of our own country will be just as intense as ever if not increased. The sphere of the larger animals will be further encroached upon by the smaller animals and the chemists. We should find a more stable farm population with attention focused upon developing the farm home and building the rural community. There will be a pride in agricultural achievement. Men who succeed in this their chosen field of endeavor will receive the acclaim and accord such a success warrants. We will hear more about agricultural organizations. And, on top of it all, the farmers of the United States will still be aggressively reaching for all they can obtain of the world's markets. We as agricultural engineers certainly can do nothing less than hope and work for a virile, proud, able, independent farmer, whether working for himself or under some form of management, able to hold his own with other interests or groups in this country, yes, and the whole world.

The Land Reclamation Work of the Bureau of Agricultural Engineering[1]

By S. H. McCrory[2]

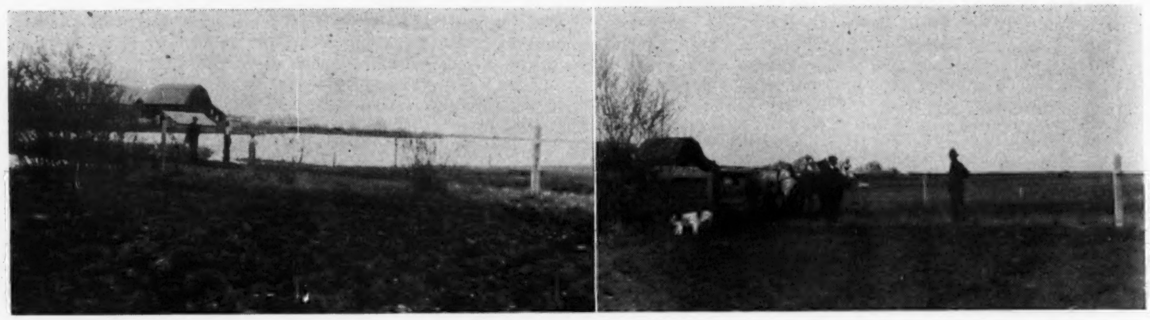
THE Bureau of Agricultural Engineering (U.S.D.A.) is vitally concerned with the activities of the A.S.A.E. Land Reclamation Division. Your chairman has requested that I tell you something of the program that we have in mind for the fields in which your interest lies, namely irrigation, drainage, the engineering phases of the control of soil erosion, and land development, including the application of agricultural engineering to the improvement of individual farms.

Before discussing our program, I should like to bring to your attention some factors that have an important bearing on all land reclamation activities. At the present time we are passing through a period of low prices for agricultural products and there are many demands for restriction of production. Never before in the history of the world have there been so many different factors affecting our need for agricultural lands. The higher standards of living which are slowly being adopted throughout the world tend to increase demands for certain agricultural products. Formerly this demand would have been largely met by increasing the area in cultivation. Now many factors enter into the problem. The data from the 1930 Census is now becoming available and it is possible to get an indication of what has happened in the United States during the last ten years. Preliminary reports indicate that the number of farms in the United States in 1929 was approximately 6,290,625, or a decrease of 157,718 during the last decade.

The amount of land in farms has, however, increased greatly. Preliminary figures are not yet available for seven states but the available data for 41 states show that the land in farms has increased from 700,217,902 acres in 1919 to 725,472,433 acres in 1929, or an increase of 25,254,531 acres. Not all of this increase is in cultivated land but undoubtedly a portion is. There has also been a shifting of crop lands. It is interesting to note that every state east of the Mississippi River shows a decrease in the number of acres in farms, while practically every state west of the Missouri River shows an increase in the acreage of lands in farms. A considerable part of this increased acreage is undoubtedly due to the more general use of the combine in the semi-arid regions, which has made profitable the cultivation of many millions of acres of land which formerly could not be cultivated profitably. In Oklahoma, Texas and New Mexico the extension of the cotton belt westward due to introduction of machine methods has undoubtedly greatly increased the area under cultivation in these states as the number of farms in each of them has substantially increased.

[1]Paper presented at the Land Reclamation Division session of the 25th annual meeting of the American Society of Agricultural Engineers, at Ames, Iowa, June 1931.

[2]Chief, Bureau of Agricultural Engineering, U. S. Department of Agriculture. Mem. A.S.A.E.



A before-and-after picture showing the benefits of tile drainage in reclaiming the flooded portion of a farm in South Dakota

The preliminary announcement in regard to the 1930 drainage census shows an increase of 19,320,462 acres, or 29.5 per cent. The irrigation census shows 19,578,441 acres irrigated in 1929, an increase since 1919 of 386,725 acres. In considering whether additional reclamation enterprises are desirable, it is not enough for the engineer to determine that these enterprises would be physically possible, but he must also consider carefully whether or not under existing conditions, or under conditions which are apt to come about in the future, such undertakings would be likely to be economically successful.

There are many reasons why we have a surplus of farm products at the present time; restrictions on immigration and decreasing birth rate have retarded increase in population. Competition from abroad is cutting off foreign markets. The number of horses and mules on farms in the United States has decreased from 25,199,552 in 1920 to 19,476,000 in 1929, while during the same period the number of tractors has increased from 246,083 to 852,989. Substitution of mechanical power for animal power continues and it is impossible to forecast to what extent our farms will ultimately be mechanized.

The development of a process for drying hay at low cost is apt to have a far-reaching effect upon the demand for additional lands. Not long ago a prominent dairyman told me that this year he was harvesting 90 acres of high-protein rye on his farm and that the use of a drier had made possible the growing of this additional crop without otherwise changing his crop rotation. The use of commercial fertilizers increases the yield per acre, and by their more widespread use it is possible to increase greatly our production of crops without increasing the acreage.

Undoubtedly, as the control and prevention of erosion becomes more widespread, and the rate at which land becomes worn out is retarded, the amount of land withdrawn each year from cultivation because of depleted fertility will be decreased. All of these factors tend to reduce the demand for new land and indicate that in planning reclamation projects we must be more conservative in forecasting the future demand and more careful in estimating the costs of the development and the time required to bring the lands to full production.

As to our research program in the Bureau of Agricultural Engineering, we shall endeavor to make this strong and shall attempt to anticipate the needs in each field, so far as possible, in order that our studies may develop needed information as required. The work of the irrigaton division will be continued along the same lines as in the past under the leadership of W. W. McLaughlin, chief of the division. Perhaps the three most important lines of work in this division will be those dealing with the duty of water, engineering-economic problems involved in irrigation undertakings and the irrigation problems of the individual farmer.

The division of drainage and erosion control, under the leadership of Lewis A. Jones, will continue work along much the same lines as those followed in the past. Probably the most important activity in this division at this time is that dealing with the engineering features of the control of erosion. There is no more important problem than this before the American farmer today, and on its solution will depend to a considerable extent the permanence of American agriculture. This work will be carried forward as rapidly as funds permit. It is hoped we will be able to broaden the field of our work somewhat and include some engineering studies on erosion which lack of funds has heretofore prevented. The work on run-off from agricultural lands, and hydraulic factors affecting the capacity of drainage channels, will be continued as well as studies on underdrainage. There is no more important drainage problem than that of maintaining the ditches and drains which have been constructed and which today represent an investment of more than $682,000,000. Too little attention has been paid to this in the past with the result that the rate of deterioration has been rapid. I am convinced that, if systematic maintenance were practiced, the cost of drainage to the country as a whole would be materially reduced.

For several years, under the leadership of George R. Boyd, we have been working on the problem of developing existing farms to make possible more effective and economical operation. Surveys are made of individual farms to determine what agricultural engineering has to offer them. The end in view is that each farm shall be a well-balanced unit. Crops, livestock, physical condition of fields, farm machinery and farm buildings should each be in proper proportion to the others, in order that the farm income may be increased to the fullest possible extent. Studies along this line have been undertaken in Minnesota, North Carolina and Georgia, and are being planned in other states. The results of these preliminary studies have been surprising. On 18 farms in northern Minnesota containing a total of 181 fields, the average size of the field was 4 acres; on 10 farms in one county in North Carolina there were 219 fields having an average size of 2.03 acres. On one farm surveyed there were 30 fields with an average size of 1.06 acres. How can any farmer use modern equipment and low-cost methods of production on farms such as this? On another group of farms in a good farming community in southern Minnesota, it was found that by comparatively inexpensive rearrangement, the average size of the fields could be more than doubled. We plan to explore further into this field and find out what can be done toward making the farms more efficient and profitable by improving drainage, by terracing, by clearing and by consolidating fields and arranging them so that modern low-cost methods of production can be used. If by readjustment we can make unprofitable farms profitable, is this not better than to abandon them and start anew elsewhere?

In closing, let me say frankly that we in the federal department of agriculture are far more concerned in enabling our 6,250,000 farmers to carry on successfully on the land they have, than in adding to the present cultivable acreage by bringing in new land. We intend to shape our entire research program around that thought and there is ample field here also for the activities of the Land Reclamation Division of the Society.

The Philosophy of Agricultural Engineering[1]

By J. Brownlee Davidson[2]

AS AN introduction to my paper I would like to tell you a story taken from the book of imagination. The plot may in some respects resemble those of certain stories popular with children, particularly boys, like "The Swiss Family Robinson," but no attempt has been made to imitate.

Once upon a time a group of people were shipwrecked upon an isolated, uninhabited south sea island. Their ship was completely wrecked and they were entirely isolated from the rest of the world. A preliminary investigation revealed that the island was fertile and productive, stocked with animals and fowl, and had many undeveloped resources.

As only a limited amount of supplies were saved from the wreck, the first task of the group was to provide themselves with the primary necessities of life — food, shelter, and clothing. On account of the meager facilities available for performing the necessary tasks involved in securing the necessities of life, the entire time of all the group was required to secure enough food and shelter to keep body and soul together. In fact, the history of the early experiences of these people indicated that there were oftentimes famine and want.

As time passed, certain members of the group devised implements and methods for doing the various tasks which greatly increased the output of their effort. So great was the increase that not only did the group have an abundance of the necessities, but it was no longer essential for all of the group to work at the cultivation of plants or the husbandry of animals to secure an abundant supply of food. Certain individuals were released from these tasks and were permitted to specialize in the production of clothing, the building of shelters and other commodities. In this manner, manufacturing had its beginning on the island.

As progress continued, through the domestication of animals and their use for power, the output of the worker providing food and other products of the land used for shelter and clothing, was increased to the extent that many of the group were released for the building of roads, vehicles and ships, and the development of transportation systems. As the years went by, stores of fuel were discovered, and fuel-burning motors developed, the power of which was utilized by means of machines to still further reduce the number of workers required for agriculture, and workers were released for education—the task of giving to the coming generation the benefits of the experience of the past.

As the years passed, still further progress was made in increasing the productive capacity of the workers, until it was possible to give attention through specialization on the part of certain individuals to the fine arts—music, painting, and sculpture. Time also became available for recreation and play. Leisure time became available and was utilized to promote the general well-being of all. My story would fail in being true to life if it were not recorded that there were periods of distress as has always been the case in the history of world progress. As improvements were made, there were times when less people were needed in certain activities than formerly and these were compelled to seek employment in new fields. Class consciousness developed and the various classes tried to regulate their activities and production for their own advantage and the disadvantage of the other groups.

In relating this story taken from imagination I have tried to depict the development of civilization. This self-contained community formed by an isolated group on a south-sea island went through the various stages of development through which man has passed in the course and progress of civilization. With certain setbacks and periods of distress due to unbalanced conditions, progress has been made to the point where all members of society are blessed with many of the facilities and service which contribute to well-being.

It will be recognized that the group in the isolated community, who contributed in a large way to the general advancement of the community by finding efficient methods, were the engineers. It is ridiculous to claim that the engineer is wholly responsible for the progress of civilization, but it is right to claim that he has contributed in a very large way to its advance. No better evidence can be furnished of this than the willingness in some quarters to blame the engineer for the periods of distress which frequently occur during the onward march of civilization and which may be properly looked upon as growing pains.

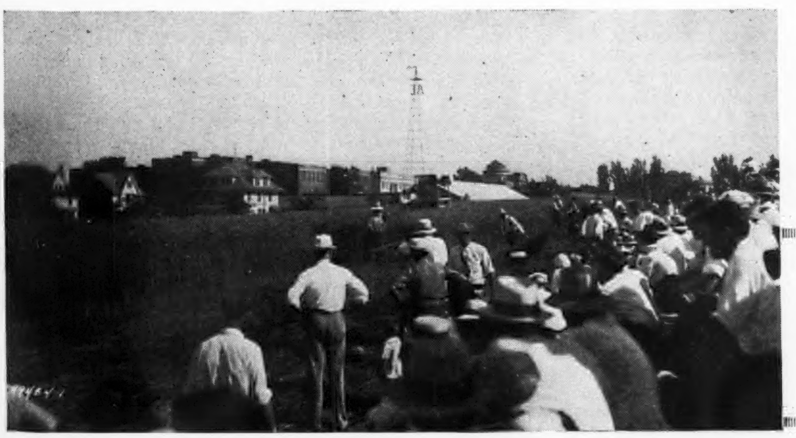
It is the purpose of this paper to briefly review the method and philosophy of the engineer; to inquire into his work and its relation to the advance of civilization; and to ask if the engineer has not responsibilities and opportunities which he has not assumed, and if the job, even from the engineer's viewpoint, has been as complete as it might have been.

As a background to the discussion which is to follow, it might be desirable to quote a conventional and accepted definition for engineering: "The art of organizing and directing men and the utilization of the forces and materials of nature for the benefit of mankind." In other words, the engineer is a silk worm, and the spinning of artificial silk costs less in effort than unwinding raw silk from cocoons.

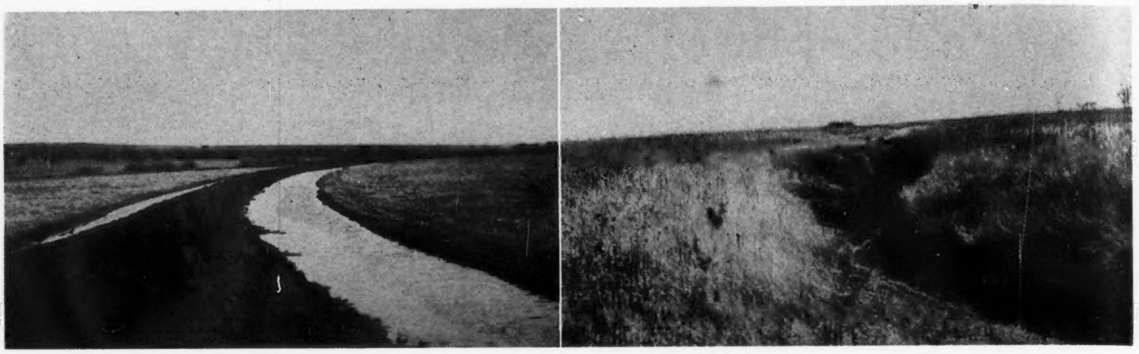
The third principal field of activity of the engineer is to multiply the output of human effort by the application of power. The process began when early man subdued an animal, perhaps an ox, and tied it to his crude plow. It continued to the present use of fuels and the power of waterfalls. The application of power to conserve labor and increase output is something to cogitate about. Man as a motor is hopelessly outclassed. A strong man can develop about one-eighth horsepower, an insignificant amount when output is desired. A man may travel with his own energy about 2½ miles per hour. With power in an automobile on a good road it is practicable to travel 60 miles per hour, and even 220 miles per hour has

[1]Paper presented at the 25th annual meeting of the American Society of Agricultural Engineers, at Ames, Iowa, June 1931.

[2]Professor and head of the department of agricultural engineering, Iowa State College. Charter A.S.A.E.



A snapshot showing a small section of the audience watching the cradlers in the A.S.A.E. pageant of harvesting progress at Ames



Terraced land—one result of agricultural engineers' efforts to reduce waste and make the efforts of farmers more effective

been attained. The principal cause for the difference in speed is power.

The output of the worker the world over is directly related to the amount of power utilized per worker. In China most of the workers work without any assistance in the way of a motor. The production under such conditions may be considered unity. In France with the power used per worker it is estimated that the output is increased 8¼ times; in Great Britain, 18 times; and in the United States, 30 times. To use an illustration frequently used, every American worker has the equivalent of thirty slaves at his command.

The utilization of energy has resulted in an enormous output of the worker, and this increase has been the means of advancing well-being. Well-being is here intended to include specialist in labor—the organization and direction of men; in power—the forces of nature; and in materials—the materials of construction and manufacture. Regardless of the branch of the profession to which an engineer may belong, the motive and objective of his work is to utilize labor, power and materials to produce efficiently goods and services to supply human needs; to make life more comfortable, surroundings more pleasant, environment more livable; to facilitate travel, transportation and communication, and to provide opportunity for culture and advancement.

The engineer contributes to these objectives in three ways. One is by doing a thing so well that it does not need to be done over again for some time. For instance, water may be carried from a well to the house in a pail and the requirements for water may be such that the trip to the well and return may be repeated several times in a day. By stretching a pipe, an elongated container from the well to house, with a pump to move the water in the pipe, the container does not need to be moved or replaced. The selection of the right kind and quantity of materials makes the installation permanent.

The second way in which the engineer works is to reduce waste and to make effort more effective. The cleaning of grain, removing weed seed, reduces waste of effort in growing a crop. The building of a hard-surfaced road reduces the waste due to rolling resistance to a wheeled vehicle. Artificial silk has an appeal because it obviates the necessity of looking after the worthwhile values of life as well as the prerequisites of comfort, pleasure and happiness.

There have been but few attempts to my knowledge to set forth in a clear manner the idealism upon which we are attempting in this country to support a social structure. President Hoover in his little book, entitled "American Individualism," has made one of the few efforts to explain the "American soul." In his book he contends that we as a people are willing to let each and every individual develop his own faculties and abilities to the fullest extent. The only restriction insisted upon is that every individual shall have an equal opportunity. Our public educational system is predicated upon the principle that all shall be given an equal chance to prepare for a life of service.

As engineers interested in the industry of agriculture, it is proper that we consider the relation of engineering to this industry. Viewed in an abstract way, agriculture is the industry committed with the production of food and raw materials, used for food, shelter and clothing. As these are basic needs, all persons in all situations are interested in agriculture. This is perhaps best evidenced by the interest of government in agriculture. As a background it may not be out of place to analyze the primary objectives for agriculture when viewed from the national standpoint. On a former occasion I enumerated these as follows:

1. Adequate quantity of production
2. High quality of agricultural products
3. Low cost of production
4. Well-being of those engaged in agriculture.

It is not practicable to discuss these objectives except in a very brief way but some explanation may be expected. It is a matter of national concern that there be an abundance of agricultural commodities. The interest of government in agriculture is unquestionably due to the importance of an abundance of food and other agricultural products at all times. History indicates clearly the relation between food supply and national stability.

The desire for quality in agricultural commodities is rational and justified. It is not only important that there be plenty to eat but also that the food be wholesome and healthful.

Not only is it important that we have plenty of food of good quality, but it should be available at a cost which will permit even those less favored in income to have plenty. If low cost were not important, the public interest in agricultural production would not be justified, for high prices would guarantee an adequate supply.

The cost of food is not a burden at the present time. A comparison of food cost per capita with taxes, for instance, is favorable, for in some cities the taxes exceed the cost of food. As far as the United States is concerned, no doubt a moderate increase in the cost of food would be no particular burden.

When attention is given to the well-being of the persons engaged in agriculture, we find the problem of the time, for rural folks in general do not enjoy as large a measure of well-being as people in other situations. In well-being it is intended to include all of those conveniences, comforts and values making for a higher standard of living, such as plenty to eat and wear, comfortable and convenient homes, efficient education, recreation, cultural interest and community spirit.

If the well-being of the farmer and his family is the present problem, how may the situation be improved? To me two things seem necessary: (1) The farmer must desire a higher standard of living, and (2) when the desire is present, he must have the income to realize that desire. If the income exists without the desire for a higher stand-

ard of living, well-being is not advanced because the extra income is used to increase competition within the industry and agriculture is overcapitalized.

Following the general trend of my theme, it is important to point out the relation of engineering to income. This has been effectively indicated by the equation which for any commodity is

Income = (Selling Price minus Cost of Production) times Quantity

$$I = (P - C)\,Q$$

Where a number of commodities are produced, the total income is made up of the sum of the incomes from each. The individual farmer can not control P, the selling price, except as it is related to quality. He does, however, have much control over C, the cost of production, and Q, the number of units produced.

As the study is continued, it is proper to analyze the cost of production. Now, for the production of any commodity in manufacturing, say,

$$C = M + L + P + O$$

where C = cost of production
M = cost of raw material
L = cost of labor
P = cost of power
O = cost of overhead

For agriculture a slightly different equation seems more applicable, viz.

$$C = Ld + Lb + P + M + O$$

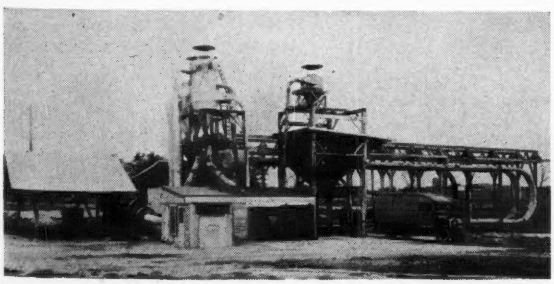
where C = cost of production per unit of area
Ld = cost of use of land
Lb = cost of labor
P = cost of power
M = cost of machinery
O = miscellaneous cost

The separation of the cost of producing farm crops into these items is stimulating. For instance, in growing corn in central Iowa, the cost per acre is about as follows:

Use of land	$9.00	45 per cent
Use of labor	4.50	22½ per cent
Use of power	4.50	22½ per cent
Use of machinery	1.00	5 per cent
Miscellaneous	1.00	5 per cent

Thus it is made clear that the use of land is a very important item in the cost of production and represents the price farmers are willing to pay for the privilege of farming. Naturally it follows the price of agricultural products. In the long run the farmer will make approximately as much money growing corn at 50 cents as he will at $1.00. To illustrate, if the yield per acre in the illustration cited is 50 bushels, the cost of production is 40 cents per bushel. If the selling price is 50 cents the profit is 10 cents. If, however, the cost of the use of land is $34.00, the cost of production per bushel will be 90 cents, and if the corn is sold for $1.00, the profit will be the same, or 10 cents. If corn should go to $1.00 a bushel and remain there, we might expect the cost of the use of land to advance considerably.

Thus in our social system of individualism, the group furnishes the competition but certain individuals set the standard of achievement by increased efficiency. These individuals by increased income provide the standards which others strive for.



A Koon forage drier installed on Brook Hill Farm, Genessee Depot, Wisconsin—another example of agricultural engineers' efforts to reduce waste

The most serious problem which arises in connection with this advance of civilization due to the application of engineering and better agricultural practice which increases the output per worker, is that fewer and fewer workers are needed in agriculture. The less efficient under economic pressure, or the more ambitious seeking more inviting fields, are influenced to leave agriculture for other vocations. In the long run this is desirable, for in a self-contained community the fewer people required to produce the agricultural commodities, the better, because the individual income of those employed will be higher and those employed in other industries can produce services and commodities contributing to the general well-being of all. It is in making these adjustments we, as a nation, muddle through. We have periods of great prosperity and periods of grave depressions. We have periods like the present when people are hungry and farmers have plenty but cannot dispose of it at a profitable price. In the long run civilization moves forward. The masses have more than they would have otherwise, but advances are made through a series of wild advances and setbacks, and during the latter there is undue suffering.

The question arises, Does the engineer have any responsibility in connection with this problem? He is blamed in many quarters for the depression although no thinking person wants to forego the fruits in better living that engineering has furnished. To turn back to less efficient methods for the express purpose of keeping people busy is nonsensical. Legislation appears to be futile and business is dumbfounded.

Is not the time ripe for the engineer, in cooperation with other groups, to take a part in the task of keeping the economic machinery running smoothly? What can be said in his favor? The engineer is accustomed to getting the facts in any problem and acting therefrom. Engineering is essentially a profession of action, of taking care of new situations. The engineer has faith and courage. He is accustomed to doing things that have never been done before.

It is generally appreciated that the best way to prevent depressions is to prevent riotous prosperity. The crash of the stock market has as a background excessive dividends. The agricultural depression may be laid to the door of land inflation. Whether we want it or not, the stage is set for more regulation than ever before in the history of the country. Shall or shall not the regulation be administered by men trained and experienced in engineering work?

Should the engineer make a contribution toward developing an appreciation of conscientious public service? I was greatly impressed during my stay in Russia with the way that, when all other avenues of advancement were cut off to the ambitious, public service attracted the best talent and the best effort in the country. The punishment of the betrayal of a public trust should be made more severe and the reward for faithful service be made greater.

Engineering rather than business methods must be carried into public regulation. Perhaps you have noticed how business men often get into trouble upon taking up public work. In business it is proper to trade favors. A business man conducts business with those who will favor him in similar transactions. In public affairs everyone must be treated fairly and public interest be given first consideration.

It would appear that the agricultural engineer may have a just reason to feel proud of his contribution to the progress of American agriculture and that he may properly take credit for helping in making some of the benefits of civilization available to the masses. To be blamed generally for the distress of depression and unemployment is only undeniable evidence of the effectiveness of his service. As we approach the problem of providing the necessary regulation to keep our economic machine running smoothly, and the making of the necessary adjustments of employment, the agricultural engineer should as a service to his country take his share of the responsibility.

Proper Storage Facilities for the Safe Keeping of Wheat[1]

By R. H. Black[2]

INCREASING use of the combine harvester with a shortened resultant threshing season for wheat has increased interest in the farm storage of wheat. Two main reasons exist for the storage of wheat on the farm: (1) To hold market wheat for better prices, premiums, or a more convenient time for hauling, and (2) to provide seed wheat for the next planting season. In either case, the wheat should be placed in such storage as will be economical in construction, conveniently located, designed for low-cost handling of the grain, and of such construction as will prevent the heavy losses which frequently are due to heating of the grain in the bins, to rodents and to deterioration of the structure itself.

No one type of building will meet the requirements of all localities or even of all the farms within a similar large area. The suggestions which follow however are generally applicable and will be of assistance to architects designing farm storage, and to farmers who erect such storage.

Storage for the safe keeping of wheat should be placed on a well-drained site, preferably with the ground sloping away in all directions. If a natural slope is not available, an artificial slope should be provided. If possible the storage should be located conveniently with respect to the movement of trucks or wagons from the fields and to the market.

The amount of space required depends upon the amount of wheat ordinarily stored. When additional temporary storage is required it can be quickly constructed to take care of an unusually large crop, often at a less expense than for the permanent type of storage which is desirable for the safest keeping of wheat.

A standard bushel of wheat occupies approximately 1¼ cubic feet of space and weighs approximately 50 pounds per cubic foot. The capacity of a bin, in terms of bushels may easily be calculated by multiplying its volume (length by breadth by depth) by 8 and dividing by 10.

In addition to grain storage space, provision should be made, in permanent storages, for space and equipment needed to facilitate the handling of grain in conditioning, cleaning, grading, treating and grinding. The space and equipment will vary with the individual needs.

In nearly every area especially where combines are used, one ventilated bin as described in U. S. Department of Agriculture Farmers' Bulletin No. 1636, should be included.

The foundation of a building for storing wheat safely must be sufficiently large and strong to carry the heavy load which is imposed upon it. Settling of the foundation causes cracks in buildings and loss of grain by the rain or snow which work through. Since a cubic foot of wheat weighs approximately 50 pounds, a bin having a floor measurement of only 10 by 10 feet and filled 8 feet deep weighs approximately 20 tons. After calculating the volume of the storage and the weight to be carried by the foundation, the necessary sizes of footings and sills can be determined.

The height of the foundation should be such that the sills and floor joists are at least a foot above ground to prevent deterioration of the wood, and to allow for proper circulation of air underneath the bins.

Sidewalls may be of wood, metal, concrete or tile. Wooden sidewalls may be either of crib or balloon construction and may be sheathed with wood or metal. The type, thickness, strength and method of bracing the sidewalls is dependent upon the height of the structure and should always be designed with a large factor of safety. The roof may be either wood or metal, in either case all roof joints must be rain and snow tight. Floors should be grain tight and of material which does not splinter or become damaged from the use of grain scoops or shovels.

Vents should be provided in the upper part of all kinds of grain storage to allow the escape of moisture which rises from the grain. These vents should always be screened to prevent the entrance of small animals or birds. Damp grain may also be stored in ventilated bins previously mentioned.

CONCLUSION

Most of the wheat storage which has been found satisfactory has failed from lack of attention to one or more of the above points.

Any farm building designer can successfully plan proper storage facilities for the safe keeping of wheat by using common architectural information coupled with the information contained herein, which applies specially to wheat storage. Proper storage facilities are not much more expensive than poor storage facilities, and preserve the wheat without loss.

U. S. Department of Agriculture, Farmers' Bulletin No. 1636 "Farm Bulk Storage of Small Grains" issued in October, 1930, will be of assistance in planning the details of safe storage facilities for wheat.

[1]Contribution to a symposium on "Problems in the Efficient and Economical Farm Storage of Grain, Corn and Rice" at a meeting of the Structures Division of the American Society of Agricultural Engineers, Chicago, December, 1930.

[2]Senior marketing specialist, in charge of grain cleaning investigations, U.S.D.A. Bureau of Agricultural Economics. Mem. A.S.A.E.

Economics of Storing Grain on the Farm[1]

By E. J. Bell, Jr.[2]

HOW to provide additional facilities for handling the crop is one of the most perplexing problems of the grain producer. Recent changes in havesting and hauling methods have almost revolutionized the marketing system at country shipping points. Before the days of combines, grain was stored temporarily in shocks. When the combine is used, grain is in position to be moved to market as soon as it is cut. Furthermore, motor trucks and road improvement enable the grower to move the crop much more readily than before.

In the days of dirt roads and wagons, all grain except that produced within a few miles of the railroad had to be held at least temporarily on the farm. Improved hauling methods and surfaced roads make it possible to move the crop directly from the thresher or the combine to the country elevator at distances of thirty miles or more.

With these changes in technique, growers have tended to abandon the use of farm granaries. This tendency has resulted in congestion at country shipping points and at terminal markets. It has placed a severe strain on railroad facilities and has increased the costs of handling the crop.

Authorities differ as to the influence of large visible supplies upon the level of grain prices. Members of grain exchanges and many economists hold that the speculative market is usually able to absorb heavy receipts at a particular market without undue depression. Others claim, not without justification, that extremely heavy movements have a depressing effect upon futures as well as upon cash markets.

Whatever belief one might hold relative to the effect of large visible supplies on the future markets, there can be little question of the effect of terminal congestion upon cash prices. During the week ending August 30, 1929, the cash price of number two hard winter wheat at Chicago averaged 14 cents per bushel under the December future, and 20 cents under May. During the same week, the cash price of number one northern spring wheat at Minneapolis averaged 12 cents per bushel under the December future and 19 cents under May. Such unprecedented carrying charges could be accounted for only by the congestion at terminal markets and the demand for storage space.

Under such conditions as these, there has naturally been a need for additional storage facilities. Such facilities may be provided at terminal market centers, at subterminal diversion points, at country elevators or on the farms. One editorial writer has pointed out that all types of grain storage, farm, country shipping point and terminal, must be developed together. Each type is a necessary part of the system.

So much for the general storage problem. We are here to discuss the place of farm storage in the broader program and the information which the engineers and the economists may have upon the subject. From the standpoint of the farmer, he may either store his grain temporarily on the farm or he may move it directly to the railroad shipping point as soon as it is threshed or combined. What are the advantages and disadvantages in each case?

[1]Contribution to a symposium on "Problems in the Efficient and Economical Farm Storage of Grain, Corn and Rice," at a meeting of the Structures Division of the American Society of Agricultural Engineers, at Chicago, December, 1930.

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The change from the above method of threshing to direct combining was a large factor in precipitating the grain storage problem

REASONS FOR FARM STORAGE

There are several conditions under which grain is stored on the farm. Some of these conditions are so obvious that they hardly seem worthy of mention but it will be desirable to have them in mind.

First, if hauling facilities are not sufficient to move the grain to the shipping point as rapidly as it is threshed or combined, farm storage is, of course, necessary. Even when it would be possible for the farmer to move his crop immediately, congestion at the local shipping point sometimes necessitates keeping a portion of the crop in farm granaries, at least for a short period. Such use of farm storage facilities may have a supporting influence on the market for cash grain. The grower who is able to hold his crop until such congestion has been relieved is often in a more advantageous position than if he had sold at a time when cash prices were depressed.

A second reason for farm storage is to keep separate high quality grain. During the rush of movement to market it is often impossible to keep such grain separate in crowded country elevators. Under such conditions, it is impossible for the elevator manager to return the full amount of the premium to the grower of an exceptional product. By holding the grain in a bin on the farm until after the rush of market movement, the grower can often sell to better advantage than by marketing through congested facilities.

A small amount of grain might also be held on the farm for conditioning. When the country elevators are crowded, it is often impossible to take care of wet grain. An occasional load of such grain might well be put in a farm granary equipped for drying. If the volume of such grain is large, however, it may be more economical to condition it at country shipping points, at sub-terminals or at terminals. Present information does not seem adequate to decide this point definitely. The practicability of conditioning grain on the farm depends somewhat upon the kind of grain. For example, ear corn can be dried on the farm much more readily than wet wheat. The particular situations under which it is practicable to provide facilities for conditioning different kinds of grain on the farm must be determined in part by engineers.

The expense of constructing storage on the farm is generally lower than that of constructing elevators. Whereas farm bins holding 1,000 bushels can be constructed for \$90.00 to \$150.00 or at a cost of 9 to 15 cents per bushel, country elevator storage often costs from 25 cents to \$1.00 per bushel. Other costs of handling grain on the farm tend to offset somewhat the apparent advantage of lower initial costs of construction, as will be pointed out later.

The need for adequate farm storage space for cleaning and conditioning seed wheat cannot be overemphasized. The losses to grain producers from grain that is high in dockage amount to millions of dollars annually. Smut,

weevils, and garlic are other sources of great loss to growers. Sprouted kernels and heat damage lower the germination of the seed and also result in loss. Proper cleaning of seed grain is essential to weed control. Proper treatment is the only effective method of reducing smut losses. Control of insect pests and moisture damage is dependent upon the right kind of storage facilities. In connection with this phase of the problem we need help from the agronomist as well as from the engineer.

The need for farm storage of feed grains is so obvious that it needs little further discussion. Oats, corn, barley, rye and other grains have always been fed largely on the farm where grown. The present outlook indicates that wheat should also be considered as a feed grain and in some parts of the country, more farm storage space may be necessary on this account.

In addition to the reasons for farm storage mentioned above, one or two other arguments are often advanced. It is claimed that the practice keeps the grain under control of the grower. In this connection, attention may be called to the fact that with the development of marketing agencies owned and controlled by producers, it is not necessary for growers to store grain on the farms in order to keep it under their control. Cooperatives can retain control of the commodity from the time it leaves the farm until it is finally sold to the mill or exporter without resorting to farm storage.

There is also a theory that grain held on the farm will convince the grower that a surplus exists and be a more forceful argument for making acreage adjustments than if the grain is stored beyond his immediate ken. The writer gives little weight to such supposed educational advantages of grain stored on farms as a means of convincing producers that a surplus exists. Price levels such as the present ones should be sufficient warning to grain growers that adjustments in production are necessary.

DISADVANTAGES OF FARM STORAGE

Why, then, in the face of such obvious advantages, is not all grain stored on the farm until it is ready to be milled or exported? Why do many farmers leave their bins empty and move their grain direct to the local shipping points from the threshing machine or combine?

Among the reasons why farm storage is not followed more extensively, particularly in the case of wheat, is the fact that farm storage adds to the total cost of marketing. The added expense to the total cost of marketing arises from the fact that the grain must be shoveled from a truck into a farm granary and then later shoveled back into the truck. Interest and depreciation on the building, insurance from fire and the natural shrink of the grain are additional items of expense. After these expenses of farm storage have been incurred and the grain is put back on the truck, it is in exactly the same position as when it left the combine or threshing machine and must still be moved to the local shipping point and handled through the country elevator.

It has been estimated that the annual cost of storing grain on the farm amounts to about five cents per bushel. The following table shows how the various items of cost involved in farm storage might be computed. An instance has been selected where a thousand-bushel bin cost $150. Some of the expense items such as rate of interest are arbitrary and may vary under different situations:

Interest on bin at 8 per cent	$12.00
Depreciation on bin, 10 per cent	15.00
Insurance and shrinkage, one cent per bushel	10.00
Cost of two extra handlings, 1½ cents per bushel	15.00
Total cost, 1000 bushels	$52.00
Cost per bushel up to 12 months	5.2 cents

In view of these extra costs of farm storage many growers prefer to move the crop directly to the shipping point. In the judgment of some students of the subject, it would be a better paying proposition for growers to invest their money in a cooperative elevator association so that additional facilities could be constructed at the country shipping point rather than to provide the same amount of storage space on the farm. This is just another way of saying that the increased cost of handling grain on the farm more than offsets the lower construction costs of farm granaries. It is also of interest to note that terminal market congestion can be alleviated as readily through providing additional storage space at country shipping points as by storing grain on the farm.

Furthermore, road conditions in the grain belt are generally favorable for hauling at harvesting time. Later in the season rains and snow often make roads impassible, and if grain is held on the farm it is difficult or impossible to move it. On the other hand, if the grain is held at the railroad siding it can be moved to market at any time, regardless of the weather or road conditions.

Bankers often feel that grain stored on the farm is no better collateral that the other security which the farmer is able to offer. The need for cash to defray production and harvesting costs is often a factor which limits farm storage. In some states farm storage certificates are issued by state departments of agriculture. These certificates can sometimes be used by cooperative marketing organizations to secure funds from intermediate credit banks. Thus through their cooperative associations, growers in some states can secure advances on grain stored on farms. Where this is possible one difficulty of farm storage can be overcome.

Facilities for drying and cleaning grain on the farm are often rather limited. Certain types of ventilated bins will keep the grain from spoiling but large volumes of wet grain are sometimes difficult to handle by such methods. Hence if a farmer has a large quantity of grain which is not in condition to store on his farm, it is generally necessary for him to move it to some point where it can be dried promptly. Farm machinery is usually adequate for cleaning a few hundred to several thousand bushels, but where larger amounts of grain are produced, many farmers prefer to have this done at country shipping points or at terminals. Perhaps it will be feasible for the engineers to develop cleaning or drying machinery whereby larger volumes can be conditioned on the farm.

SUMMARY AND CONCLUSIONS

It has been pointed out that farm storage is only a part of the general problem of handling grain. There are several conditions under which grain can be handled satisfactorily on the farm: (1) Farm storage is necessary when local elevators are congested or when hauling facilities are not sufficient to move the crop as rapidly as it is threshed or combined; (2) farm storage is often necessary in order to keep separate high quality country run grain; (3) under some conditions grain can be dried or cleaned to advantage on the farm; (4) the per bushel cost of constructing farm granaries is often less than that of constructing country elevators; (5) facilities must be provided on the farm for cleaning and treating seed grain; and (6) when grain is to be fed to livestock, farm storage facilities are necessary.

Factors which tend to discourage the use of farm storage are: (1) It adds to the total cost of marketing; (2) it is costly or impossible to move grain from the farms if roads are bad; (3) grain stored on the farm is less desirable as collateral for loans than if stored in a public elevator; and (4) efficient machinery for conditioning and cleaning large volumes of grain cannot be provided on the farm as readily as in country elevators.

Certain economic phases of the problem require assistance from the engineer. Under what circumstances should grain be dried on the farm and when should it be dried at the country shipping point or at the terminal? When should market grain be cleaned on the farm, when should it be cleaned at the country elevator, and what type of machinery should be used in each case? There is a very definite need for farm storage facilities which will preserve the viability of seed grain and which will preserve the quality of grain which is to be marketed.

Storing Rough Rice in Bulk in Concrete Terminals and Country Elevators[1]

By G. P. Bodnar[2] and E. N. Bates[3]

THE rough rice of California is stored generally in sacks in flat warehouses, primarily because this is the customary method of handling other Pacific Coast grains. There are very few elevators in the state equipped for handling and conditioning rice and grain. Another probable reason for the continued use of the sack system in place of the bulk system of storage is that very few people whc handle the sacked rice are aware that dry rough rice can be stored successfully in bulk.

While the weather conditions at the time of rice harvest in California are usually excellent, still wet seasons occur from time to time when large quantities of rice have to be harvested and stored in a damp or wet condition. During such seasons very heavy losses are sustained from sacked rice going out of condition because of excessive moisture. During such years attempts are always made to keep rice from spoiling by cutting open the sacks and piling the loose grain on the warehouse floor where by means of shovels the rice is moved and handled at intervals to prevent damage by heat. The handling operations involved in trying to keep such sacked grain in condition are both slow and expensive. In a bulk grain elevator rice or grain can be kept cool at a small cost by moving it from one bin to another by machinery, or by running it over cleaners, if necessary, where the air blast will maintain a low temperature. Obviously, if the elevator is equipped with a drier, the grain can be put in storage condition.

The introduction of the windrow and direct combining methods of harvesting rice in California are adding complications to the storage problems of rough rice in the state since not much information has been available on the moisture condition of the rice thus harvested.

In California in the fall of 1927 the rains came before the harvest and much rice was either left unharvested, or was harvested in a damp condition with the result that it was a year of heavy losses due to rice spoiling while in storage in sacks in warehouses. During that season about 3,000 tons of damp bulk rough rice were handled and conditioned at a concrete terminal elevator. Because of the high moisture content of the rice, some of the lots containing as high as 25 per cent moisture, the rice had to be dried before placing it in permanent storage. The handling, drying and storing of this rice was done slowly at first because of the limited knowledge of the factors involved at the start of the work, but the tests, experiments, and observations on the cleaning, drying and storing of this large quantity of rice revealed the information necessary to permit successful handling and storing of such rice.

The following information regarding the conditioning and storing of rough rice was obtained by the grain investigations division of the U. S. Department of Agriculture.

A half carload of cool rice with a moisture content of approximately 23 per cent was heating very badly when removed from the bin after two weeks of undisturbed storage. Its temperature had risen to over 130 F. The discharge of the rice was accomplished with difficulty as it was sticky and sour.

A single carlot of rice having a moisture content of approximately 19 per cent was heating very badly after fifteen days of undisturbed storage. The rice as discharged from the bin had a temperature in excess of 125 F, was sticky, steaming, discolored to a rich orange shade and had the characteristic sour odor of heating rice.

Rough rice at 60 F with a moisture content of 18 per cent, stored in a concrete bin 20 feet in diameter, developed considerable sweating in less than a week of undisturbed storage.

Rough rice binned with a moisture content of 17 per cent and an initial temperature of about 70 F, developed considerable sweating and a temperature of 90 F after an undisturbed storage period of 10 to 14 days.

Cool rough rice with a moisture content of 16 per cent did not show signs of sweating after periods of storage up to five weeks. Rice of this moisture content was usually moved from one bin to another about once a month to reduce the chance of damage.

It is a wise precaution to frequently move rice of high moisture content. Rice containing 18 per cent or more of moisture should be moved from bin to bin every few days until it can be dried, milled or blended with dry rice. Rice with 17 per cent moisture and a temperature of 70 F or lower should be moved at least every ten days. Rice with 16 per cent moisture at 70 F or lower should be moved at least once every three to four weeks.

The observations noted indicate that the length of time rice will store safely increases very much faster than the decrease in moisture content indicates. For instance, rice with 18 per cent moisture developed considerable sweating in a period of less than one week, and

[1]Contribution to a symposium on "Problems in the Efficient and Economical Farm Storage of Grain, Corn and Rice," at a meeting of the Structures Division of the American Society of Agricultural Engineers, at Chicago, December, 1930.

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[3]Senior marketing specialist, U.S.D.A. Bureau of agricultural engineering. Mem. A.S.A.E.

sweating developed in 17 per cent moisture rice in less than two weeks, whereas 16 per cent moisture rice showed no sign of sweating in a period of more than four weeks. An operator of a bulk storage plant for rice may vary the suggested procedure on the basis of his experience under varying climatic conditions. However, in the absence of experience one will do well to use the above information as a guide.

In a test of rice storage at a concrete farm elevator in the Sacramento Valley a bin of rough rice with an average moisture content of 11 per cent was stored undisturbed for a period of nine months from October to July, without damage other than that caused by rain seepage through defective walls. The initial temperature of the rice varied from 50 to 95 F. During this period of storage atmospheric temperatures ranged from approximately freezing temperatures at night to possibly more than 95 F during the day in the late spring and early summer months. When this particular bin of rice was discharged from the elevator the first ten truckloads showed signs of considerable weevil infestation in its early stages traced to the use of grain sacks at the elevator, for bagging screenings, which had been in use in the farm feed-grinding plant known to be very heavily infested with weevil.

Since the wet rice harvest of 1927, rough rice has been stored in bulk by rice milling concerns in California in increasing amounts. Dry sacked rice is received at the mill or elevator in carload lots. An experienced rice man at the elevator directs the binning of the rice for satisfactory milling purposes. Moisture tests are made of questionably damp lots and if they are of too high moisture content for safe storage, the lot is binned separately for suitable disposition or attention.

If any question whatever exists as to possible keeping quality of rice in a large bin on account of having some lots of questionably high moisture, it is a good precaution to draw the bin about three weeks or a month after the rice was binned to assure good condition and to thoroughly mix the rice. The thorough mixing is probably desirable not only for insuring its keeping quality but also to produce a more even product for milling purpose.

Attention may well be called to the necessity of avoiding the mixing of any other cereal grains with rough rice. Special care must be used in seeing that used grain bags are entirely clean if they are to be used for rice. Freight cars used for shipping bulk rough rice must be scrupulously cleaned of all other grain. Boots of elevator legs, screw conveyors, and bin walls and bottoms must be thoroughly cleaned before being used for rough rice.

Storage Facilities for Safe Keeping of Rice[1]

By J. D. Long[2]

RICE is one of the two cereal crops in California which, because of the season of harvesting, present a storage problem due to moisture content. Our other grains harvested during the arid summer months leave the field "bone-dry," but the October-November harvests of rice and milo maize may find higher atmospheric humidities and precipitation with the result that the grain does not dry on the stalk. As with the cereal crops of the mid-west states, the application of the combine to the harvest of these problem crops has somewhat aggravated the situation. The incipient change from sack to bulk storage added to the combining problems has directed still more attention to the moisture storage relationship.

Under the prevailing harvesting system in California, rice is cut with a binder, shocked, threshed into 100-pound grain sacks, and stored in the sacks in warehouses. During the time the grain is in the shock it is expected to cure to a moisture content safe for storage, but frequently this is not accomplished. The high moisture grain in the warehouse requires attention when it begins to heat. The sack pile is torn down and repiled, or the grain dumped out on the floor and shoveled over to cool it. Occasionally a consignment of sacked rice in the 17 to 20 per cent moisture range may go safely through the winter months with an atmospheric temperature range of approximately 25 to 60 F. and then begin to heat in the spring when atmospheric temperatures strike 80 F or above.

Storage is not generally recognized among rice men as a very serious problem, even though the conditioning of the occasional lots is both slow and laborious, and the treatment of the entire crop, in wet years, impossible.

The harvest of 1927 found an exceptionally wet fall in the Sacramento Valley. Rice delivered to the warehouses that fall had "water running out of the sacks." Millions of bushels spoiled in the warehouses and were used for hog feed. Experiments run that fall in the Oakland elevator, California's only commercial terminal elevator, by G. P. Bodnar, are summarized in the accompanying paper by Bodnar and Bates.

Direct combining is just coming into favor, approximately 15 per cent of the rice crop of the Sacramento Valley being so harvested this season. Early in the season, before the winter rains start, or throughout the season if the rains are late, the combine may take some well-cured grain from the fields. Later in the season one must expect a range of 20 to 25 per cent. Such percentages practically require bulk handling, with its attendant machinery and equipment to permit low-cost moving and airing of the rice in storage or mechanical driers. Two driers, one imported from Italy and the other homemade, have been operated in the Sacramento Valley rice area this season. If the harvest dates can be moved earlier in the season, as now seems possible with the use of airplane seeding and combine harvesting, the storage problem may be eliminated.

In unventilated bulk bins the tendency to heat is naturally greater than in the sack piles; apparently a 2 per cent moisture differential may effect similar results. Incidental observations on storage made in conjunction with harvesting by E. J. Stirniman[3] and Roy Bainer[4] in 1929 and by Bainer in 1930, set 14 to 15 per cent as the allowable maximum for bulk storage. They have found too that occasional lots of damp rice placed in storage with drier rice may dissipate the excess moisture without harmful results. Fifteen tons of 18 per cent rice placed in the middle of a 200-ton metal bin during 1929 failed to indicate any appreciable temperature rise in three weeks.

Protection of rice from rodent and insect depredations is effected in the same manner as for other cereals. An individual characteristic is the protection required to avoid mixture with other grains, particularly barley and wheat, which it is almost impossible to remove from the rough rice. Since admixtures greatly lower the quality of the milled rice, it is necessary to use separate harvesting, storing and shipping facilities for rice, or exercise extreme care in cleaning the storage and handling equipment.

[1]Contribution to a symposium on "Problems in the Efficient and Economical Farm Storage of Grain, Corn and Rice," at a meeting of the Structures Division of the American Society of Agricultural Engineers, at Chicago, December, 1930.

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[4]Assistant agricultural engineer, California Agricultural Experiment Station. Assoc. Mem. A.S.A.E.

Some Problems in the Storage of the Southern Rice Crop[1]

By W. D. Smith[2]

AS THE size of crop of any kind of grain increases and it becomes necessary or desirable to hold a part of the crop out of consuming channels for a time after the crop is harvested, men become interested in places to put the grain. At first, very little thought is given to any feature of a storage place except capacity. The first thought is usually to find some place, or to build a place, which is big enough and strong enough to hold the grain that is to be stored.

The lines of least resistance are often followed at first and if a makeshift storage place is available it is usually used. If none is available, a storage place bought ready-built, or one that is easy to build, is used. Very seldom do we find consideration being given at first to safe keeping of the grain. Consideration may not be given to this phase of storing until something occurs which causes the owner to think in terms of safe storage. This "something which occurs," unfortunately, may be the spoiling of a bin full of grain. When spoilage occurs in storage the owner of the grain gives immediate thought to how he can store his grain so he can be reasonably sure that it is going to come out of storage in as good condition as when it went in.

In the southern rice territory there are probably no rice storage problems that do not exist in some of the grain producing areas but some of the problems are more acute or more accentuated in the rice belt of the South than they are in the grain sections of the North, East or West.

Before discussing storage facilities for rice I would like to discuss the grain itself, in order that some of you who possibly are not familiar with this cereal and the manner in which it is handled and milled will more readily appreciate what I have said about some of the problems of storage being acute or accentuated. Rice is produced almost exclusively for human consumption. Very little rough rice and very little milled rice is fed to stock or is used for any purpose except as food for human beings.

After the rice kernel is threshed it has on it the bran, the germ, and a very tough silicious hull. All of these must be removed in milling so that the rice will have the white appearance which it has when it is sold in the grocery stores. In the milling of rice it is desirable that as many of the kernels be preserved whole as possible, as the whole-grain rice brings a much better price on the market then broken rice. Inasmuch as most of the rice kernels are whole after milling and the appearance of a lot has a great deal to do with its salability and price it is highly desirable that there be as few defects (damaged kernels) in the rice as possible. A damaged kernel shows up very plainly in the mass of white rice and if many damaged kernels are present they may have the effect of prejudicing the wholesaler, retailer, or consumer against the lot that is being offered for sale. Heat-damaged kernels of rice are of a mahogany color after they are milled and it will be readily appreciated that such kernels would be very noticeable among the white kernels.

In the states of Louisiana, Texas and Arkansas, where the southern rice crop is produced, climatic conditions must be given very careful consideration in planning storage places and in handling stored rice. The harvest season for rice extends from July, in the early sections, to November and December in the late sections and the humidity during these months is often high. During this season some of our readings at a point in southeast Texas where we were conducting some investigations showed the temperature to be 96 to 99 F with a relative humidity of 80 to 84 per cent. In New Orleans, for the week ending November 15, the average daily temperature was 67 F and the average relative humidity was 91 per cent. It is not uncommon during rainy harvest seasons for the rice

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Rice is a grain which has always involved moisture problems in storage. These problems have been added to by changes from sack to bulk handling methods and from binding to combining

to sprout in the shocks and in the bags after it is threshed. Occasionally, during long warm rainy periods, the rice will sprout from the heads while it is standing uncut in the fields. All during the early part of the winter there are likely to be periods in southwest Louisiana and southeast Texas when the temperature is high enough to cause rice which contains excess moisture to start heating while it is in storage. Aeration of the rice in such cases will help temporarily but if the temperature and humidity of the outside air are high, aeration cannot serve for more than temporary relief.

All of the rice produced in Louisiana, about 90 per cent of the rice grown in Texas, and about 20 per cent of the rice produced in Arkansas is handled in sacks. Bulk handling is confined to about 10 per cent of the Texas crop and to about 80 per cent of the Arkansas crop, or about 19 per cent of the entire rice crop of the South. Consequently, any discussion of proper storage facilities for rice in the South must include something in regard to sack storage as well as bulk storage.

Because of the high humidity in the southern rice territory and because of the wide range in temperature during the storage period, with quick changes from cold to warm, special consideration must be given to the material from which the granary or warehouse is to be constructed. It is highly desirable that the storage place be built of a material on which condensation from the humid atmosphere will not take place. In sack warehouses, which are seldom constructed to exclude the outside air, the condensation on the under side of a metal roof sometime drips on to the piles of sacked rice, the condensation on the metal side walls and on the floor will dampen any sacks which come in direct contact with it, unless the roof, the sides, and the floor are made of a material on which condensation does not readily occur.

After rice has been in storage for some time in sacks and is shipped, particular attention is usually given to the sacks on top of the piles and along the sides of the warehouse. Very often these sacks of rice have damaged spots or "pockets" in them. This damage in most cases is caused by water dripping from the roof or by water running into sacks where the sacks came in contact with the side of the warehouse. In the case of metal bins or tanks for bulk rice, condensation will also take place on the under side of the roof and along the sides. Even if the outside humid air is excluded from such storage places, there may be just enough moisture escape from the stored rice to condense and cause damp or wet spots at the top or along the sides.

In the South most of the recommendations of the United States Department of Agriculture and most of the forms of storage recommended by commercial firms have been tried. Many storage ideas of individual growers and warehousemen have also been tried and, of course, many mistakes have been made which have served to show what must not be done.

During recent years the idea of ventilated storage places has gained greatly in favor and no one would have the temerity to suggest that aeration is not good for stored grain under favorable conditions, but ventilators accomplish little or no good under certain unfavorable conditions which exist so often in the southern rice producing areas. Places of storage should be equipped with ventilators but there is no doubt that the ventilators should be kept closed a great deal of the time in the rice sections of the South.

Ventilators in bins or warehouses should not be left open when the atmospheric humidity is abnormally high. It is especially undesirable to allow warm air of high humidity to circulate through cold rice, because the moisture content of the rice may be raised through condensation. Some of the sacked lots of rice that are stored in warehouses in the South each year would keep better if it were possible to exclude all outside air whenever atmospheric conditions were unfavorable.

If one will go into the rice producing section of Arkansas, where a large part of the crop each year is handled

The problem of developing proper facilities for the storage of grain crops of all kinds has been forced on the attention of the producers much more in recent years than ever before

in bulk, one will note an abundance of granaries and small elevators constructed of wood and will note the almost total absence of storage places made of any material other than wood. Most of the storage places are built of wood because little condensation takes place on this material. Many of these bulk storage places in Arkansas are equipped with various forms of ventilators but the ventilators are usually used only when atmospheric conditions are favorable.

In Louisiana and Texas, where practically all of the rice crop is handled and stored in sacks, one will see many warehouses constructed of materials other than wood but in most cases one will also find that care is being taken to see that there is an open space between the sides of the piles of sacked rice and the sides of the warehouse. The evil in that area of the condensation dripping from the roof is not receiving the attention that it should.

There is no gainsaying the fact that warehouse floors should be made of concrete, because of their greater durability and because of the rat-proofing feature, but warehousemen and others who have given the matter of safe storage very much thought are elevating the piles of rice some six or eight inches above the concrete floors by means of timbers or wood platforms.

It may be of interest to you also to know that in New Orleans, and possibly some of the other larger cities in the South, many lots of milled rice are moved into cold storage in the early spring months. This is to prevent the development of weevils in the rice and has proved to be a very effective means of preventing infestation. Because the warm weather extends over such a long period in the South the problem of the control of weevils is a serious one with both rough rice and milled rice. Weevils are eliminated from the rice temporarily when infested rough rice is milled but if infestation occurs after the rice is milled it is necessary to fumigate or re-mill the rice, or both.

No lot of rice, or any other grain can be stored intelligently in bulk or in sacks unless the moisture content is known. It is comparatively easy for any experienced rice man to tell when a lot is quite dry or quite wet without a test of any kind but it is not easy to tell when a lot contains only slightly too much moisture for safe keeping unless an accurate moisture test is made. Often lots that are supposedly dry spoil in storage because of excess moisture. The dangerous lots are those which are thought to be dry but which contain just enough moisture to induce spoilage.

Through an official inspection and grading service that was established a few years ago and which is under the supervision of the United States Department of Agriculture all of the rice producers who are members of a large rice growers cooperative association in the South are receiving grade certificates covering their rice. These certificates show the moisture content of each lot of rice and this information has been of great value as a guide as to whether rice could be stored for any extended period or how it should be stored. In the South, where probably a slight excess moisture in the rice may have a greater effect on stored rice than it would have on stored grain in other sections, the growers and others interested in rice are being guided more and more by the moisture test to determine whether any given lot of rice is safe for storage. Possibly if accurate moisture tests were made available to growers in all sections it would help as much as anything else to insure the proper storing of all grains.

New Developments in Dairy Refrigeration[1]

By L. C. Prickett[2]

AS MILK and cream are cooled, bacterial rates of increase are diminished accordingly until at a critical point for milk of around 50 degrees (Fahrenheit), or 40 degrees for cream, multiplication is so slow that at or below these temperatures reasonably long periods of storage are practical.

Bacterial growth is most rapid at temperatures of from 70 to 100 degrees, and while such growth practically stops at freezing, some few bacteria even at this temperature continue to develop slowly. When temperature conditions again become favorable normal activity is resumed. Actual freezing of milk must of course be guarded against because of resulting changes in physical characteristics and greatly impaired quality.

On many farms the time between cream shipments is close to a week. The critical cooling and storage temperature under such conditions is around 33 degrees. Major sources of contamination in order of their general importance are (1) unsterilized or dirty utensils (including milking machines and cream separators); (2) foreign material or dirt from the cows' flanks, udder, etc., and (3) contamination from insects, the stable air, and the foremilk from the cows' udder.

Fresh milk which is cooled to 50 degrees or less within three or four hours (precooling or stirring not necessary) and stored at a temperature of 35 to 40 degrees will not increase in bacterial content during the first 12 hours. The greater care required after this time is apparently due in part to the gradual impairment of the germicidal qualities found in freshly drawn milk. However, even low count milk will sour or even clabber within a very few hours if allowed to stand at high temperatures (70 to 100 degrees). Very little milk need be held by the producer for more than 12 hours, or, at most, 24 hours.

Cream must be cooled below 40 degrees in two to four hours if excessive bacterial growth during the first day is to be prevented; in fact even with rapid cooling to 40 degrees and storage at 36 degrees the bacterial counts increase greatly by the end of 90 hours. However, cream in wet storage below 40 degrees for four days cannot be distinguished in flavor and general quality from the same grade six hours old. Cream cooled to 36 degrees in three hours and stored at 33 degrees or less will have a bacterial count below the initial count at the end of 90 hours. When cream shipments are a week or more apart such rapid cooling and low temperature storage is essential if best quality cream is to be produced. Even when cream is cooled slowly, to 44 degrees in 12 hours, and held at 36 degrees after 24 hours, it will grade "No. 1 sweet" for butter at the end of 90 hours.

Some type of cooler or aerator is commonly used with a dry storage box often as an integral part of the installation. Less frequently coolers are also used with wet storage systems.

Aerators should be of the two-way type with water passing through the upper half and brine through the lower half, allowing approximately 6 inches of horizontal length for each 10 gallons of milk cooled per hour.

Where an abundant supply of cold water, 50 degrees or below, is available, milk is frequently cooled and sometimes stored by the use of water only. One dairy farmer in New Hampshire pumps the water from a shallow well through the milk cooler with a ¼ horsepower motor and a small pump. The maximum energy consumption in a typical year was around 10 kwh (kilowatt-hours) per month in July and August, and the minimum around 4 kwh in February. The average per month for the year was around 7.8 or 2.6 kwh per month per 100 quarts per day, 300 quarts being cooled daily. From 2.5 to 3.5 kwh per month for each 10 cows in milk should be sufficient for cooling when pumping from a shallow well. Where water is also used for storage the energy consumption will be from 50 to 100 per cent greater than reported above. Cooling the milk to around 65 degrees with the water coils will generally about double the cooling capacity of the available refrigeration.

A ½-inch centrifugal brine pump driven by a ¼-hp motor is sufficient where less than 200 gallons of milk per day are cooled, but where 200 to 400 gallons of milk per day are cooled a ¾-inch centrifugal, driven by a ¼-hp motor, will be required.

TYPES OF MILK BOXES OR TANKS AND COOLING UNITS

Refrigerated storage may be either of the "dry" or "wet" type, the former being more generally useful (butter, eggs, meat, vegetables, and food from the house being among the other products often stored there) and is especially favored by retail dairymen.

The use of tanks containing refrigerated water is especially favored by wholesale dairymen. considerable refrigeration being stored and the first cost being lower than for equivalent dry storage. Available data does not indicate any necessity for forced circulation, but with it undoubtedly the milk could be cooled in warmer water at the same rate, as compared to natural circulation with colder water.

A dry storage box should have an allowance in floor space of 15 by 15 inches for each 10-gallon container that is to be stored, or where the milk is in quart bottle cases a space of 16 by 20 by 12 inches for each case.

Small herds of 12 to 15 cows and large herds of 24 to 30 cows will ordinarily produce a daily average of 12 and 24 pounds of butterfat which will make around 5 gallons and 10 gallons, respectively, of 30 per cent cream.

Dry storage boxes are cooled in two general ways: (1) By the brine system and (2) by the direct-expansion system. The direct-expansion system is generally more efficient than the brine system, but, since it lacks storage capacity, has a materially lower rating under ordinary operating conditions. Under the first system there should be from 1.5 to 2 gallons of brine per gallon of milk cooled daily, the strength and nature of the brine (usually cal-

[1]This is an abstract of a comprehensive paper on the subject of dairy refrigeration which will later be published in complete form by the Committee on the Relation of Electricity to Agriculture.

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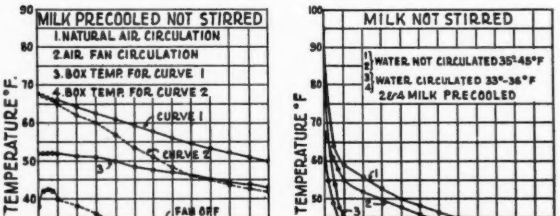

Fig. 1. Milk temperature curves (12) for the first 12 hours of storage with different types of refrigeration of 40 gallons of milk in 10-gallon cans. (Left) Dry storage, top-opening refrigerator. (Right) Storage in refrigerated water

cium chloride) is specified by the refrigeration equipment manufacturers.

Dairy cooling units commonly use sulfur dioxide, methyl chloride or ammonia as the cooling medium or refrigerant, but ammonia plants are generally the most efficient. Due to the manufacturing difficulties ammonia plants are usually available only in the larger sizes. Where a moderate and dependable supply of cool water is available and a fair-sized installation is needed, equipment with a water-cooled condenser should be purchased as this type is materially higher in efficiency than the air-cooled type. Plans for homemade boxes and tanks are often furnished by manufacturers of materials and can usually be obtained from the local power company.

For sanitary reasons all dry storage boxes should be coated inside with at least one-half inch of concrete. A heavier coat (2 inches) is more desirable as it is less apt to crack, but in any case it is best to use some reinforcement such as coarse chicken netting tacked onto the frame. A proper waterproof coating will also protect the insulation from moisture.

Under most conditions good insulation will pay for itself in a single summer's operation through reductions in energy costs. Compressed corkboard is used almost exclusively for the insulation in dairy refrigerator tanks and boxes, but there are several other materials which are almost as good except for the difficulty of keeping them dry. Moisture reduces the efficiency of all common heat insulators.

The size of motor and compressor required to handle a particular dairy refrigeration job will depend upon many factors such as the amount of ice required, gallons of milk cooled and method used, type of cooling system, and whether it is air or water cooled. Obviously the manufacturer's advice should be sought before an actual purchase is made.

Just as for power requirements the energy consumption of dairy refrigerating equipment will vary greatly with such factors as amount of ice used, gallons of milk cooled and methods used, and quality and size of storage box or tank. The average for wet storage is around 1.0 kwh per 10-gallon can of milk cooled and stored. For dry boxes where the brine system is used, the average per 10 gallons of milk is around 1.2 kwh for cooling and storing; 1.7 kwh where the milk is cooled and then stored in bottles; and 0.9 kwh where the milk is cooled but not stored. For dry boxes equipped with direct-expansion units the average energy consumption is around 0.5 kwh per 10 gallons of milk, regardless of whether the milk is merely stored or both cooled and stored. Obviously in every case the requirements vary greatly with the outside temperature. Data from a very limited number of large-sized Texas dairies show energy consumption 15 or more per cent below the averages from the California survey in which only a few of the dairies were large: 0.6 kwh per 10 gallons cooled; 0.7 kwh per 10 gallons cooled with an aerator and stored in a "wet type" storage tank; and 1.4 kwh per 10 gallons cooled, bottled, and then stored in a "dry" walk-in box.

Under practical conditions it will require considerably more electrical energy for cooling and storage than for storage alone. In cases where water ranging from 40 to 60 degrees in temperature is available, the electrical energy requirements for cooling can be materially reduced by pumping this water through part or all of the cooler. Some rather typical figures for cooling and storing from New Hampshire show an average energy consumption of around 0.8 kwh per 10 gallons of wholesale milk and a monthly energy consumption for retail milk of 60 kwh per 100 quarts handled daily. In many cases the cooler or aerator is designed so that part of the coils use water and the remainder brine from the refrigeration system.

Where boxes or tanks are not used to full capacity or are poorly designed or located the energy consumption will be high. For example, a well-insulated New Hampshire dry storage box so located that the morning sun shines on the side walls has an average energy consumption 9 per cent above that for a similar box with noticeably poorer insulation, but located in a protected corner of a shallow basement.

According to some figures from a 2-ton ammonia plant operated by a 7½-hp motor in Alabama, 3 kwh will replace 100 pounds of ice. Data from California show the effect of room temperature, daily number of times the doors are opened, type of load, defrosting cycle and ice coil, and size and location of doors on the energy consumption, and operation of general-purpose refrigerators with a net storage capacity of 50 cubic feet and insulated with 3 inches of cork.

COST OF DAIRY REFRIGERATION

As a general thing a good ice house will cost nearly as much as a refrigerating unit with its box or tank, and when the labor, sawdust, etc., required to fill the ice house are considered, the operating costs for electrically cooled dairy refrigerators are considerably below those for ice refrigeration. Some actual farm costs from New Hampshire show ice refrigeration costing a total of from 45 to 156 per cent more than electric refrigeration, even though the average cash cost of electric refrigeration was an average of 137 per cent greater than for ice refrigeration. The average total cost per cubic foot of total contents was $1.18 for the ice method and 62 cents for the electric. The cost per 100 quarts of milk (based on one year of operation) was 30 cents for the ice method and 15 cents for the electric. The comparative costs of concrete tank or wet storage installations should be still more favorable.

Under the favorable conditions for ice storage found in Vermont, mechanical refrigeration (dry-storage type) was generally more economical, there being little difference with ice at $2.00 per ton in the ice house when electricity was 5 cents per kwh, but with ice at $3.00 per ton in the ice house and electricity at 5 cents per kwh the latter was materially cheaper.

Estimating electric power at 2 cents per kwh, deprecia-

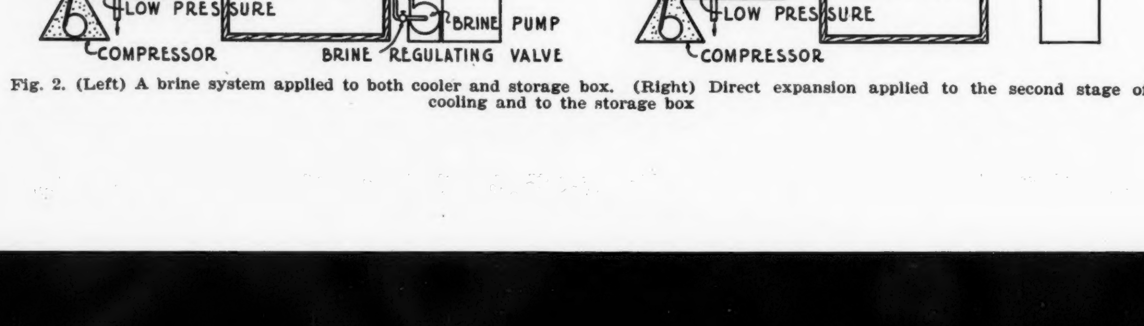

Fig. 2. (Left) A brine system applied to both cooler and storage box. (Right) Direct expansion applied to the second stage of cooling and to the storage box

tion at 10 per cent, interest at 7 per cent, and upkeep at 3 per cent per annum, a milk-cooling plant will cost from ½ to 1 cent per gallon cooled, depending on the size and type of plant and the method of handling the milk.

It is less expensive to cool milk below 50 degrees in a tank-type cooler with mechanical refrigeration using electricity at 3 cents per kwh than with ice at ½ cent per pound.

The total cost of ordinary electric dairy refrigeration installations varies from $400 to $1,000 or more. They are seldom less than $400 even when homemade.

A concrete-lagged box in Wisconsin, 7 feet 6 inches long by 4 feet 8 inches wide and high enough to accommodate 8 and 10-gallon cans, cost about $125.00, and the refrigeration unit about $700.00, making a total of $825.00 for the installation. The sides and bottom are insulated with 3-inch corkboard on either side of which is 3 inches of concrete, the cover being made of two layers of board and one of building paper.

SUMMARY AND RECOMMENDATIONS

1. Milk and cream are cooled to retard bacterial increase and preserve quality.

2. Cooling milk and cream on the dairy farm is required by state and city regulations for the production of market milk. An increasing number of companies are offering premiums for quality, which often pay the entire cost of refrigeration and the total electric bill in addition.

3. Mechanical refrigerating machines are an efficient and economical means of accomplishing this cooling, if equipment of the proper size and type is used.

4. Two types of milk cooling plants are in use, the "wet" and the "dry". The "dry" type, used almost entirely in California, may be either a brine or direct-expansion system. The "dry" type is commonly used by retail dairymen and the "wet" type is frequently favored by wholesale dairymen. The total installation cost of the latter is lower, the concrete tank frequently being homemade.

5. The bacterial content of milk will not increase during the first 12 hours when kept in 10-gallon cans in a tank of water at 35 to 40 degrees without precooling. With cream, nothing larger than 5-gallon cans should be used. Fresh cream should never be poured into old cream until completely cooled and the storage temperature should not be above 33 degrees. Butter should be stored at 2 degrees or lower. (U. S. Department of Agriculture Bulletin No. 729 gives recommended storage conditions for fruits, vegetables and other farm produce.)

6. Stirring milk in 10-gallon cans set in water at 35 to 40 degress does not materially increase the rate of cooling. Water should reach the neck of the cans, and there should be a ratio of water to milk for night and morning cooling (with cans in place) of 3 to 1 and 4½ or 5 to 1.

7. Milk, after being drawn from the cow, is usually handled on the farm in one of three ways: Cooled and stored in 10-gallon cans and shipped to the distributing plant once a day; cooled and stored in bottles and delivered once a day; or cooled and shipped to the distributing plant after each milking.

8. The electric power consumption for the operation of a farm milk cooling plant depends upon the method of handling the milk, the time of the year, the type of plant or system, and the construction and operation of the plant.

(a) When the milk is cooled and stored in 10-gallon cans, the brine system being use, about 0.12 kwh is consumed per gallon of milk.

(b) When the milk is cooled and stored in bottles, the brine system being used, 0.17 kwh is consumed per gallon of milk.

(c) When the milk is cooled and not stored, the brine system being used, about 0.09 kwh is consumed per gallon of milk.

(d) When cooled and stored or not stored, the direct-expansion system being used, about 0.05 kwh is consumed per gallon of milk.

9. The annual average energy requirement for cooling 100 pounds of milk below 50 degrees in an insulated tank type cooler is approximately 1 kwh. In typical cases the requirements were 5 kwh per month per 10 gallons of wholesale milk, cooled and stored daily, and 60 kwh per month per 100 quarts of retail milk cooled and stored daily.

10. Estimating electric power at 2 cents per kwh, depreciation at 10 per cent, interest at 7 per cent, and upkeep at 3 per cent per annum, a milk-cooling plant, will have an operating cost from ½ cent to 1 cent per gallon cooled, depending on the size and type of plant and the method of handling the milk.

11. It is less expensive to cool milk below 50 degrees in a tank-type cooler with mechanical refrigeration using electricity at 3 cents per kilowatt-hour than with ice at ½ cent per pound.

12. Texas data show an operating cost for electric cooling of slightly more than one-half that for ice cooling; with ice at 35 cents per 100 pounds the total costs including depreciation, etc., were 9.9 and 14.3 cents per 100 pounds, (8.2 and 11.9 cents per 10 gallons) of milk, respectively, in a typical case.

13. On three New Hampshire dairy farms the total cost of ice refrigeration ranged from 45 to 156 per cent higher than the total cost of electric refrigeration.

14. Recommendations for the selection and operation of a "dry" type of farm milk-cooling plant are:

(a) The profit that is to be gained by the use of such a plant should be determined, and the dairy

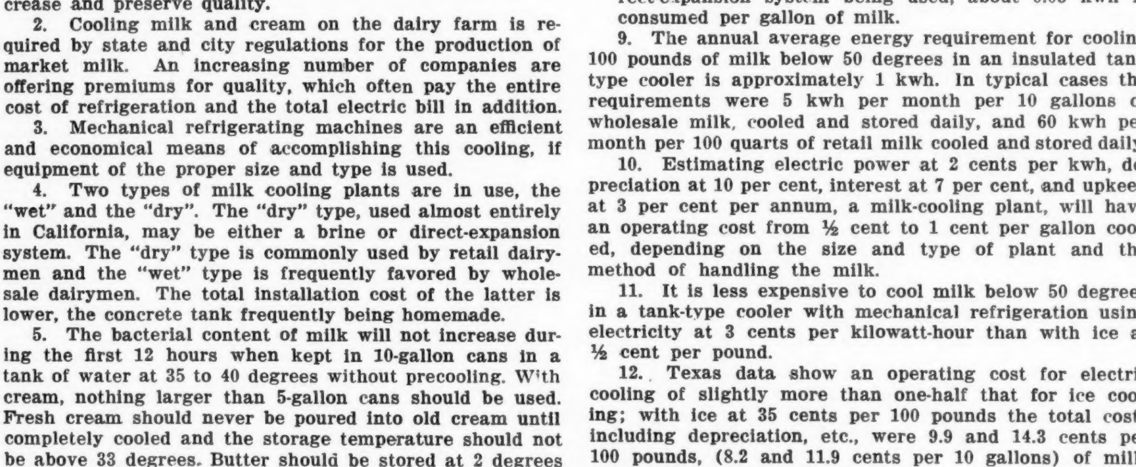

Fig. 3. Energy requirements for milk refrigerating equipment; A, Nebraska, B, California, C, southeastern states

inspector in charge consulted on the requirements to be met for producing the grade of milk desired.

(b) In purchasing the equipment one should obtain as much information as possible on the different makes and types and make a decision on the relative merits, the size of units, the price, the reputation of the manufacturer and dealer, and the service obtainable.

(c) Efficiency and length of life are as important as initial cost. Poor equipment usually means poor efficiency, and although the initial cost may be lower, the saving will be offset by increased operating cost, depreciation and upkeep.

(d) Future increase in quantity of milk to be cooled should be considered, as it is sometimes more economical to take care of future needs by installing the original plant larger than necessary at the time. Selection of proper size of refrigerating machine is very essential.

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Steam Cooling of Internal-Combustion Engines[1]

By Earl R. Young[2]

INTERNAL-COMBUSTION engines are here taken to mean the typical Otto cycle or Diesel engines. Steam cooling is a system whereby the engine water jackets are used as a steam boiler and the steam generated is (usually) condensed and returned to the jackets.

Everyone knows that an engine must be cooled, but even if an engine was made to run much cooler than any we have at present, some energy would have to be wasted. That is, not all the energy in any system can be turned into useful work. For example, no matter how a waterwheel is made, somewhere in the cycle of operations water must be discharged.

Steam cooling has been experimented with in many different ways, but the adaption to an ordinary automobile would be to lead the cylinder head outlet connection into the bottom tank of the radiator. A much smaller than ordinary pump would be used to pump enough water back into the water jackets to keep the level about at the top of the cylinders. But, you say, the engine will overheat and be ruined. What happens in the ordinary cooling system is this: When the jacket water boils, the steam and water mixture is forced up into the hottest part of the radiator and right next to the overflow. The steam down in the jackets has displaced considerable water, and having no other place to go, it goes out on the road. In a few minutes the water level has dropped below the danger point and overheating occurs. Exactly the same action would result if a coffee percolator were set on a hot stove and the top of the percolator left off.

Elementary physics teaches us that as long as water, or a mixture of steam and water, is in contact with a metal surface, that surface can not be heated above the boiling point of the water. The simplest application of steam cooling is in the common, small farm engine which is perfectly cooled as long as there is water above the cylinder.

Many experiments have shown that the parts of the engine, such as the exhaust valve seats and the valves themselves, that first become overheated in the ordinary engine, actually run cooler in a steam-cooled engine. The reason is that boiling water and steam carries heat away three to five times as fast as water not boiling. At the same time the average temperature of the engine is higher, which lowers the friction load and makes the engine more efficient.

If your car was steam-cooled, it could be made cheaper in the first place, as a smaller cooling system would care for the engine. The steam-cooled engine warms up and pulls its full load smoothly in a fraction of the time the usual engine takes. In a tight place, if a steam-cooled engine did start to blow off steam, in no case would large amounts of water be discharged. If a pound of water was lost as steam, it would take many times as much heat as if it went out as water. One pound of water heated from 170 to 210 degrees Fahrenheit takes 40 heat units away, but one pound turned into steam takes 960 or more heat units.

Even a complicated system of thermostats and shutters is a makeshift, and the average car runs too cool most of the time. This results in oil dilution and lower fuel economy, and this same engine will overheat more quickly than the steam-cooled.

[1]Reprinted from "The Student Agricultural Engineer," University of Minnesota, June 1931.

[2]Student in agricultural engineering, University of Minnesota. Student A.S.A.E.

The Dynamic Properties of Soil[1]

II. Soil and Metal Friction

By M. L. Nichols[2]

SOIL friction materially affects the life and draft of plows and other tillage implements. In the absence of literature giving specific data which could be used in studies of different designs of implements, an investigation of soil and metal friction was started in 1923 and has been continued, in connection with other research on the dynamic properties of soil, since that date. It is the object of this paper to present a summary of the findings of these studies.

The coefficient of kinetic friction was determined by pulling a flat piece of the metal being studied across a smooth soil surface. The amount of pull was measured by a calibrated spring balance. The scale reading divided by the weight of the slider gave the coefficient of kinetic friction μ'. In studies of the effect of speed on friction, the slider was drawn by a constant speed motor.

Various soils and metals were used. The soils consisted of a series of synthetic soils, composed of various mixtures of Cecil clay and sand, and a group of natural soils[3] varying quite widely in their dynamic properties. Moisture was applied to the soils by the condensation method[4]. The metals consisted of various samples of chilled iron and a group of plow steels of known composition furnished by the Brinley Hardy Manufacturing Company.

The values for friction in this paper are the average or mean values obtained from a number of determinations. They were obtained from carefully cleaned and polished metals and from uncemented soils uniformly moistened, varying but little in temperature (mean 80 degrees Fahrenheit) and free from roots and parts of undecayed vegetable matter, pebbles or other materials frequently encountered in field tillage. The soils studied, while covering a considerable range, can not be accepted as being typical of all soils in all conditions. Even with the most careful preparation there are slight variations in both soil and metal surfaces. Variations from these values, therefore, are to be expected and they must be considered merely approximate values. They are, however, well within the probable error of any draft calculations for tillage implements.

[1]Second of a series of articles setting forth the results of ten years of original research work in soil dynamics at Alabama Polytechnic Institute. Released for first publication in AGRICULTURAL ENGINEERING. Part I was published in the July issue.

[2]Agricultural engineer, Alabama Polytechnic Institute, Agricultural Experiment Station. Mem. A.S.A.E.

[3]Nichols, M. L. Dynamic Properties of Soil Affecting Implement Design. AGRICULTURAL ENGINEERING 11: 201-204, 1930.

[4]Nichols, M. L. Methods of Research in Soil Dynamics. Alabama Station Bulletin No. 229, May 1929.

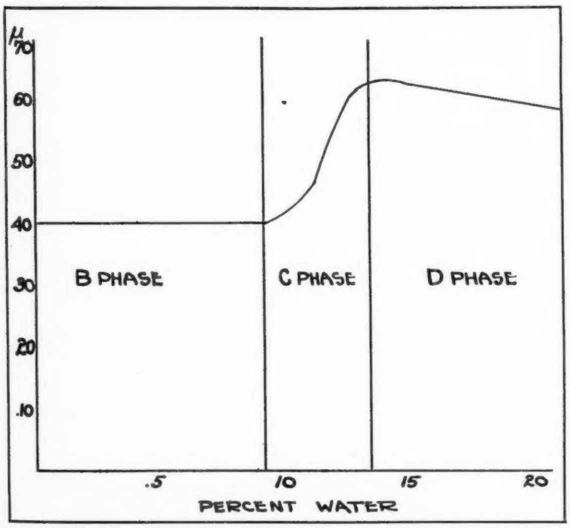

Fig. 1. A typical curve showing the effect of soil moisture on friction values. The A phase is not shown as it depends upon pressure. The B phase is classified as the pure friction phase, the C phase as the adhesion phase and the D phase as the lubrication phase

THE GENERAL LAWS OF FRICTION

Several articles [3, 4, 5, 6, 7] by the author, dealing with soil and metal friction, have been published. In these frictional resistance was divided into four phases which depended upon the pressure of the metal surface and the structure and moisture content of the soil. Fig. 1 shows graphically the relationship between frictional values and moisture content. In each phase the values of friction were found to be due to causes different from those of other phases and, consequently, each was governed by a different set of laws. The following statements of these laws show the causes of division into phases and the factors governing frictional resistance.

A (Compression) Phase. In a soil when the water does not adhere to the metal and when the bearing power of a soil is less than the pressure, that is, when the weight of the slider compresses the soil, the coefficient of sliding friction, μ'

1. Varies with the speed
2. Is proportional to the pressure per unit area
3. Varies with the smoothness of the surface and the materials of the surface.

B (Friction) Phase. When the bearing power of a soil is greater than the pressure per unit area and the soil water does not adhere to the metal,

1. The magnitude of the friction is proportional to the total pressure between the two surfaces
2. The value of μ' depends upon the roughness of the surfaces and the materials of the surfaces
3. It is independent of the area of contact
4. It is independent of the speed of sliding.

C (Adhesion) Phase. When there is enough moisture present to cause the soil to adhere to the sliding surface, but not enough to have moisture brought to the surface, then μ'

1. Varies with the speed
2. Varies with area of contact
3. Varies with the pressure per unit area
4. Varies with the surface tension of the film moisture, i.e.,
   (a) It varies with the amount of colloidal material present
   (b) It varies with the amount of water present
   (c) It varies with the temperature and viscosity of soil solution.
5. Varies with the surface and kind of metal.

[5]Nichols, M. L. The Sliding of Metal over Soil. AGRICULTURAL ENGINEERING 6: 80-84, 1925.

[6]Nichols, M. L. The Dynamic Properties of Soil, I. An Explanation of the Dynamic Properties of Soil by Means of Colloidal Films. AGRICULTURAL ENGINEERING 12: 259-264, 1931.

[7]Nichols, M. L. and Baver, L. D. An Interpretation of the Physical Properties of Soil Affecting Tillage and Implement Design by Means of the Atterberg Consistency Constants. Proceedings of International Soil Congress. Leningrad, Russia, Section 1, 1930.

D (Lubrication) Phase. Where there is enough moisture present to give a lubricating effect, μ' varies

1. With the pressure per unit area
2. With the speed
3. With the amount of moisture and viscosity of the solution
4. With the nature of the surface and kind of material of which it is composed.

FACTORS AFFECTING FRICTIONAL VALUES

Soil Factors Affecting Friction. It has been indicated by the above classification of friction into distinct phases that the bearing power and moisture content of a soil are very important factors. Both of these apparently depend largely upon the colloidal content which, as was shown in the previous article[6], determined the reactions of all soils studied.

The moisture content and structure of a soil determine its resistance to compression. This factor determines the A and B phases. Apparent specific gravity or density may be used as an index to the soil's structure. This was found to vary with the square of the colloidal content when different soils were compressed by equal forces. It was also concluded from laboratory studies[3] that each soil would come to a "normal" density when subjected to weathering conditions. If this is found to hold true for field soils, the friction phase for any pressure may be determined from their colloidal and moisture content.

The moisture content is directly responsible for the C and D phases. The moisture contents at which these phases occur depend upon the amount of colloid and the proportion of absorbed moisture to film moisture. Temperature and salts in the soil solution affect the force exerted by moisture films and so enter into frictional values. A few experiments indicated that the variations produced by these last two factors were of minor importance from a practical standpoint and their effect is not considered in this paper.

Metal Factors Affecting Friction. All of the metals used in the manufacture of tillage implements are synthetic and consequently may vary widely in composition. Their chemical compositions not only vary, but the properties of metal of any given composition may be entirely changed with different heat-treatments. For these reasons no attempt was made at an exhaustive or complete study and the investigation was limited to metals in common use. Only the general factors of hardness and polish were considered. Some light is thrown on other factors by experiments which will be briefly discussed, but these tests were not sufficient to warrant a classification of metal variables.

Indices of Frictional Values. It is necessary to apply data obtained with groups of soils or metals to other soils or metals if the findings are to be of practical importance. It was found that the colloidal content indicated the amount and place of various reactions of non-plastic soils[6] and that the Atterberg consistency constants indicated the place and amount of reactions of plastic soils[3,7].

The only index used of frictional values of metals was hardness. This was measured by the Brinell test. No suitable index of polish or smoothness was found, and, consequently, the variation produced by this factor can only be discussed as relative.

For greater ease in applying these indices to various soils, their relationships to friction values are expressed by mathematical formulas. The constants of the non-plastic soil formulas vary slightly with different compositions of colloidal material and variations in the size of non-colloidal particles. These variations which are within the probable error of most calculations for field soils, may be disregarded in practical work. They are much more important in plastic soils but are accounted for by the Atterberg constants.

EVALUATION OF SOIL VARIABLES

A (Compression) Phase. It has been shown[6] that μ' varied with speed when the bearing power of the soil was not sufficient to prevent the slider from sinking in. In this case the pull was increased by the amount of force required to compact the soil, and, consequently, the greater the speed the greater the amount of soil to be compacted. The reaction is one commonly occurring in the tillage of sandy soils. This is commonly classified as frictional resistance, although the use of the term "friction" in this connection may be questioned.

The bearing power of the soil depends upon its resistance to compression and the arch action of the soil. The value of μ' varied with the speed on a light loose sand when the weight was just sufficient to cause a slight rolling of the surface particles. The relationship of μ' to speed was found in this case to be expressed by the formula

$$\mu' = 0.010S + 0.33 \qquad [1]$$

where μ' is the coefficient of sliding friction and S is the speed in feet per minute.

The speed formula (Formula 1) was derived from experiments with dry sand which was practically free from colloid. Soils having any appreciable amount of colloid generally cement together on drying, thus increasing their bearing power so that only B phase friction is obtained. This is almost always the case[5] with dry plastic soils, where the soil breaks into lumps instead of compressing.

It is stated under the general laws of friction that the power required to pull a slider across a soil, whose bearing power was insufficient to support the slider, varied with the weight per unit area of the slider. This is due to the slider sinking into the soil. The amount of sinking in was found to be directly proportional to the weight or pressure per square inch which means that pull is a function of the bearing power of this soil in A phase of friction. The bearing power of soil will be dealt with in a subsequent article.

B (Friction) Phase. With non-plastic soils the coefficient of friction varies directly with the colloidal content. This is shown in Table I. These data were obtained with synthetic soils and a chilled-iron slider.

Table I. The Relation of Colloid Content to B Phase Friction

Colloid content, per cent	Coefficient of Friction μ'
0	0.26
8	0.36
16	0.40
24	0.47
32	0.51

An approximate formula for this relationship is

$$\mu' = 0.0076C + 28 \qquad [2]$$

where μ' is the coefficient of friction of chilled iron and C the colloid expressed in percentage. Although this formula would be expected to vary slightly both with different kinds of colloid and different sizes of non-colloidal particles, it is sufficiently accurate for practical design work with non-plastic soils.

The friction (B phase) value of plastic soils was found to vary around a mean value for all plastic soils. For chilled iron this value was about 0.50. In this case the small particles appeared to determine the value of μ' by covering the larger particles.

C (Adhesion) Phase. As the moisture films around soil particles become thicker, the moisture is held less firmly. Finally, there comes a point when the attraction of the metal is sufficient to attach the moisture to it and the films adhere to the plow surface. To slide the soil across the metal this force must be overcome and the friction curves rise rapidly. This has been classified as a phase of friction but in reality is adhesion or, as termed by Sir George Greenhill, "stiction." The moisture percentage at which this occurs depends not only upon the capacity of a soil to hold moisture but also upon the attractive force of the metal.

The percentage of moisture at which adhesion first occurs and the moisture percentage of maximum adhesion are shown in Fig. 2. These data were obtained by a nickel-

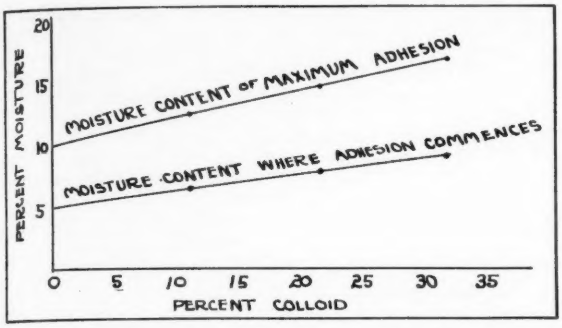

Fig. 2. The relationship to colloid content of moisture content at which adhesion commences and of the moisture content of maximum adhesion

plated slider on synthetic soils composed of Cecil clay and sand. The percentage at which adhesion first occurs depends upon the soil and metal, but the moisture content of maximum height depends entirely upon the soil provided, of course, that the metal "wets" at all. These points vary slightly with different colloids due to the amount of hydroscopic moisture absorbed by the colloid before a film becomes evident. With non-plastic soil (plasticity first became evident in soils containing about 16 per cent colloid) the colloid percentage is so low that for practical purposes this may be disregarded.

The moisture content of adhesion also varies slightly with pressure, temperature and cleanliness of the metal surface, but the variation produced by these factors appears at the present to be of minor importance in implement design. An approximate formula for the moisture content of maximum adhesion for a nickel slider on non-plastic soils is

$$M = 0.2C + 10 \qquad [3]$$

The formula for the moisture content at which adhesion first becomes evident is approximately

$$M = 0.13C + 4.77 \qquad [4]$$

In these formulas M is the moisture content and C is the colloid in percentage. The 10 and 4.77 are the moisture percentages of the maximum and starting point of adhesion for sand containing no colloid. The moisture adhesion points of various metals is discussed under the heading "Metals."

Table II. Analysis of Steels Used in Friction Studies

Sample	Brinell number	Hardness	Chemical composition (per cent) Silicon	Sulphur	Phos-phorus	Manga-nese	Carbon
Soft-center, heat-treated—							
case	2.46	618	.310	.012	.020	.540	.95
core			.06	.031	.015	.45	.10
Soft-center, heat-treated—							
case	2.53	586	.29	.011	.024	.50	.82
core			.05	.014	.013	.45	.11
Soft-center, no treatment—							
case	3.90	241	.31	.012	.020	.54	.95
core			.06	.031	.015	.45	.10
Soft-center, no treatment—							
case	4.00	229	.29	.011	.024	.50	.92
core			.05	.014	.013	.45	.11
Solid steel	3.80	271	.10	.011	.026	.58	.86
Solid steel	4.00	229	.176	.029	.042	.64	.67
Solid steel	4.50	179	.233	.024	.015	.75	.43
Solid steel	5.50	115	.080	.029	.013	.52	.17

The height of rise of the μ' curves for various non-plastic soils was shown in the previous article[6] of this series. This height is proportional to the colloidal content and depends upon the soil entirely as it represents the moisture film strength when a maximum number of films of maximum strength are grasping the metal. The approximate formula is

$$\mu' \text{ (max.)} = 0.0044C + 0.48 \qquad [5]$$

where C is colloidal content and μ' the coefficient of kinetic friction.

For plastic soils the adhesion phase was found to commence at a moisture content slightly below the lower plastic limit. This for the soils studied and a nickel slider is expressed by the formula

$$M = 0.7PL \qquad [6]$$

where M is the moisture content at which adhesion commences and PL the lower plastic limit.

The moisture content of maximum adhesion is approximately that of the upper plastic limit. The maximum rise of μ' has been shown[7] to vary directly with the plasticity number. The approximate value of the height of rise of μ' in plastic soils may be obtained from the formula

$$\mu' = 0.06\, P_n + 0.42 \qquad [7]$$

where μ' is the coefficient of sliding friction and P_n the plasticity number.

D (Lubrication) Phase. The lubrication phase of soil friction has not been carefully studied due to the fact that soils containing enough moisture to give this effect puddle badly. This puddling is not obtained with sand and may not be important when the soil is later subjected to freezing. It appears that the seriousness of puddling effects are roughly proportional to the colloidal content in non-plastic soils and to the plasticity number of plastic soils.

This lubrication of the metal surface may be produced by pressure when moisture content of the soil is high. This effect is commonly observed in the shining furrow slice. Electric currents also cause the flow of moisture to the moldboard and, as has been demonstrated by Crouther and Haines[8], this can be used to reduce the friction of plows or other metal surfaces. The relationships between the amount of electrical energy required and the decrease of draft coupled with the difficulties of applying the current makes this solution of frictional problems appear remote.

EVALUATION OF METAL VARIABLES

Metals Used. It is quite generally understood that soil friction varies considerably with different metals. To study this relationship several samples of common chilled plow iron were compared with various steel and nickel sliders. The analyses of the steels are given in Table II. The plow iron, Stellite and nickel were not chemically analyzed.

All of these metals when received had the ordinary polish

Table III. B (Friction) Phase Values of Common Plow Metals of Different Hardness and with Ordinary Polish and Selected Soils

Carbon in metal, per cent	Hardness	μ' (Coefficient of Friction) Sand, 0% colloid	Sand ½ sand, ½ clay, 16% colloid	Cecil clay, 32% colloid	Clay Susq., 55% colloid	Lufkin clay, 80% colloid
.95—SC*	618	.18	.25	.30	.31	.39
.82—SC	601	.18	.26	.33	.34	.34
.95—SC	241	.19	.29	.36	.40	.40
.82—SC	229	.19	26	.33	.42	.42
.86	271	.18	.26	.35	.37	.43
.67	229	.24	.29	.35	.35	.35
.43	179	.25	.27	.36	.41	.41
.17	116	.23	.31	.37	.42	.47
Stellite	444	.25	.35	.40	.43	
Chilled iron		.26	.40	.51	.50	

*SC—soft center

[8]Crouther, E. M. and Haines, W. B. Jour. Agri. Sci. (England) 14: 221-231, 1924.

which is applied to commercial plows. To determine the effect of polish, samples were selected and given a much higher polish by the use of emery flour and tripoli powder. No means were available for measuring degree of polish and consequently the data obtained are only comparative.

The coefficients of friction between each of these metals and the soils, previously described, were determined through a range of moisture contents. Standard Brinell tests were made to determine hardness.

B (Friction) Phase. The A phase of soil and metal friction depends largely upon the bearing power of the soil and need not be considered here. Table III gives the B phase frictional values for a series of soils and the metals studied. It was found by plotting the relationship for the first three soils, i.e., through the non-plastic range, that the value of μ' was proportional to the colloidal content. An approximate formula for this relationship with the steels was found to be

$$\mu' = 0.24 + 0.005C - 0.0001H \qquad [8]$$

where μ' is the coefficient of kinetic friction, C the percentage of colloid, and H the hardness of the metal as determined by the Brinell test. The values of μ' for the plastic soils tested were all in the neighborhood of the values obtained for the Cecil clay which contained 32 per cent colloid. It therefore appears that when a sufficient amount of colloidal material is present to cover the coarser particles, the soil friction (B phase) does not materially change with increased increments of colloid. Sufficient data is not available to determine the exact limit of C in this equation, but apparently 32 is not far from this value.

Samples of each steel were given a high polish and the value of μ' determined with each soil. This was compared with the frictional value obtained with steel having the polish commonly given by manufacturers. The results are shown in Table IV. In this table the friction values are the averages obtained from a large number (1012) of tests, at different soil moistures, with a miscellaneous group of metals and consequently are only of significance in connection with polish.

Table IV. The Effect of Polish on Friction μ' with Various Soils

	Sand	½ Sand, ½ Cecil clay	Cecil clay	Susquehanna clay	Lufkin clay
High polish	.20	.21	.23	.48	.48
Ordinary polish	.20	.27	.24	.59	.51

It is to be noted that with pure sand polish shows no effect. An analysis of the complete data, however, indicated that the high polish reduced the friction at low moisture contents. The moisture content at which adhesion first becomes evident is, however, increased by a slight polish.

C (Adhesion) Phase. It has been shown that the maximum value of μ' is due to adhesion between a soil and a metal and that this value depends entirely upon the soil moisture films. The moisture content at which adhesion occurs, however, depends upon a metal film relationship. This relationship is not well understood. It was pointed out in a previous article[5] that there are two avenues of attack on this problem: First, by the inclusion of various materials in the plow metal, and, second, by treatments of metal surfaces to reduce the attraction of the surface for moisture. Experiments conducted in both of these fields were not conclusive but a brief summary is included here to indicate something of the problem.

The attraction of a metal for a liquid may be determined by the angle of contact of a liquid placed on the metal's surface or by the way the liquid spreads over or wets the surface. Various samples of metals were obtained and the tendency of water to spread on their surfaces noted. It was found that certain metals, such as iron or steel, containing chromium or nickel, resisted wetting and that a soil must be wetter to adhere to these metals than to either common plow steel or chilled iron. The temperature and polish, as stated above, affected this relationship. It is well known that mercury when slightly contaminated is highly resistant to wetting. Attempts to use mercury on surfaces for temporary relief in push soils were unsuccessful, however, as no method could be found of combining this with metals sufficiently hard to withstand the abrasion of tillage operations. Similar results were obtained with all surface platings.

A number of experiments were conducted to determine the practicability of altering the surface energy of metals by an orientation of their surface particles. It was found that this could be done by heating and by chilling against mercury. Various heat-treatments of steels were also tried and found to effect the spreading of water on their surfaces.

The results obtained clearly show that it is possible to materially improve plow metals for push soils by selection and heat treatments of metals which are resistant to wetting. This work, however, has not been carried sufficiently far to indicate the most practical methods of accomplishing this result.

SUMMARY

Friction between a soil and metal surface may be classified by division into four distinct and separate phases. These phases depend upon the bearing power of the soil, its moisture content and the pressure of the metal surface. The colloidal content is the controlling soil factor. Approximate formulas for determining the frictional values and moisture contents at which the different phases occur in non-plastic soils were derived from friction data. In plastic soils the absorptive and chemical action of the colloidal content becomes more important and the Atterberg consistency constants are used as indices of frictional values. Formulas for determining frictional values for these soils were determined.

Soil friction values (B phase) for a series of steels, of known composition and heat-treatment, and chilled plow iron were determined. The friction of a metal was largely determined by its hardness and polish. For the soils studied

$$\mu' = 0.24 + 0.005C - 0.0001H$$

where μ' is the coefficient of kinetic friction, C the colloidal content, and H the hardness as determined from the Brinell number. When the colloidal content exceeds 32 per cent, the friction increases but slightly for added increments of colloid and this is taken as the approximate limit of that factor.

Polish is shown to affect frictional values materially in the heavier soils, but as no measure of polish was available no mathematical formula for its effect was attempted. A polish higher than that commonly found on commercial plows was found to be of no practical value on sandy soil. It was found that the adhesion of soil to plow surfaces varied with the polish and composition of the metal. Steels containing chromium or nickel were the most satisfactory of those tried. Experiments with various surface and heat-treatments indicated that the surface attraction for soil moisture may be altered but no practical method of doing this was found.

A Correction

IN THE article entitled "Comparative Effectiveness of Hand and Mechanical Corn Picking," by W. H. Carter in the July AGRICULTURAL ENGINEERING the formula at the top of page 277, showing the derivation of Fig. 3, is incorrectly printed. It should read $Y = \dfrac{X\,(43{,}560)}{72{,}500}$

Agricultural Engineering Digest

A review of current literature on agricultural engineering by R. W. Trullinger, specialist in agricultural engineering, Office of Experiment Stations, U. S. Department of Agriculture. Requests for copies of publications abstracted should be addressed direct to the publisher.

A Discharge Diagram for Uniform Flow in Open Channels, M. Blanchard (American Society of Civil Engineers (New York) Proceedings, 57 (1931), No. 1, pp. 113-118, figs. 7).—This paper presents a diagram of discharge stage and slope or fall relation for uniform flow in open channels. It is based on the Chezy formula wherein, for a constant stage, the discharge varies as the square root of the slope or fall and is designed to give the discharges at any stage for the falls that create the resulting discharges. The development of the diagram is shown by a practical application to a series of discharge measurements made in 1914-1916 on the Chicago Sanitary District Canal with regulated flows in a uniform rock section.

Tests of Farm Machines, J. G. Taggart (Canada Experiment Farms, Swift Current (Sask.) Station Report Supplement 1928, 22-32, figs. 8).—Summer fallowing experiments by different methods showed that the gang plow and the one-way disk are equally efficient in destroying the early growth of weeds on summer-fallow land and in putting the land in such shape that the duck-foot cultivator can perform subsequent operations without undue difficulty. As the one-way disk does this work at almost half the cost of plowing, it is evident that this implement has a very definite and useful place on land not too heavy and sticky for its successful operation.

Combine tests in wheat showed that the swathed grain, and particularly that which was swathed at the normal time of binder harvesting, did not dry out any earlier than did either the standing grain or grain in the shock. Good results were obtained with the header barge.

In tests of the swather and combine in oats, it was found that the swather and pick-up left 12.36 pounds of grain per acre on the ground, and the straight combine 57.2 pounds. The greater portion of the swather loss was occasioned by one swath falling partly in a dead furrow in which the pick-up was operated with difficulty. Over the remainder of the swathed portion of the field the loss was almost nonexistent. This would indicate that oats sustain a much greater loss from shelling while waiting for the straight combine than does Marquis wheat, barley and fall rye.

[Agricultural Engineering Investigations at the Alabama Station], M. L. Nichols (Alabama Station (Auburn) Report 1928, pp. 19, 20).—Experiments with field machinery in seven counties indicated that the two-mule cultivator and combination planter and fertilizer distributor are the most needed equipment in this section. It was found that one man could plant and cultivate 60 acres with this equipment. The pipe-gang, large-wheel, pivot-axle cultivator was found to be best adapted to work on bedded or furrow crops. This should generally be equipped with a set of 10, 12 and 16-inch sweeps and disk hillers. Bedding may be done satisfactorily with a cultivator, in which case a bedding bar is desirable. The fertilizer side dressing attachments were found satisfactory where new process nitrates were used, but with gummy or sticky fertilizer this equipment was unsatisfactory. The cultivator was found to be well adapted to digging peanuts when equipped with half buzzard-wing sweeps. Surveys of farm practice on the sandy land of Crenshaw County showed that "pointrows" could be eliminated by running the rows across the terraces on gentle grades. The maximum grade found where this practice was followed was on land having a slope of 14 per cent. Experiments showed that this practice was satisfactory where cotton was planted flat or where a low bed was used.

Experiments conducted in several parts of the state with a new type of terrace consisting essentially of the combination of a low mound and a shallow ditch indicated that this type of terrace can be constructed for less than one-half of the cost of the old type, broad-base Mangum terrace, and that it gives less trouble by breaking, in addition to being easier to cross.

Experiments with various equipment for plowing under vetch showed that the rolling coulter attached to walking plows was the practical and economical equipment for the one or two-mule farmer. Where sulkey plows were available, the combination jointer and coulter was most satisfactory in that the field was left in a cleaner condition. Experiments in threshing showed that a standard threshing machine with a cylinder speed of 300 to 350 rpm was satisfactory for threshing vetch.

[Agricultural Engineering Investigations at the Alabama Station] (Alabama Station (Auburn) Report 1929, pp. 19-21).—Studies by J. W. Randolph of the variation of the lug design factors affecting the traction of tractor wheels showed that the variation of the constants involved appeared to depend largely upon the colloid content of the soil. The results indicate that the general formula for figuring tractive power will hold over a wider range, if changed to include variables depending upon certain soil physical measurements. Lug depth, weight distribution, and lug volume ranked in the same order of importance for the four soils studied. Angle iron lugs which extend some distance beyond a rim will have an average of 11 per cent more traction if the flanges are attached to the rim so that they point in a direction opposite to the wheel rotation.

Studies of M. L. Nichols of the friction of soil and metal showed that the increased pull caused by the adhesion of the soil to metal was due largely to the colloid content of the soil. The place in the moisture range of soil at which adhesion took place was affected by both metal and soil. The maximum cohesive power of the soils studied was also found to be in direct proportion to colloid content. A new method of measuring adhesion of soil to metal was evolved. This consisted of measuring the capillary pull exerted by metal on water, and comparing to this the capillary pull of a metal whose adhesion to soil had been measured by the slider method.

A detailed study of the relation of compaction to pressure for four synthetic soils of known composition showed that compaction for a given force reached a maximum at some definite moisture percentage. This maximum increased as the colloid content increased, probably due to the tendency of the moisture films to form cell-like open structures. This structure appeared to be so constant for the different soils studied that the hypothesis is advanced that there is a normal soil structure for each soil depending upon these forces. Apparently the structure of soils is a function of particle size, and is a more constant property than has been generally supposed.

In machinery studies Nichols and E. G. Diseker found that various methods of plowing (including the use of the jointer and coulter), harrowing before the crop was planted, and different systems of bedding had little or no effect on subsequent weed growth, probably due to an unusually wet season. Tests of the rotary hoe, weeder, and drag harrow for reducing the labor of hoeing showed these implements to be entirely unsatisfactory during a wet season on the red Piedmont soils. Experiments with check-rowing corn and cotton showed this method to be practical on sandy, red Piedmont, and Black Belt soils having moderate grades, up to 5 per cent grade. By this method of planting, hoeing was completely eliminated. Thinning cotton planted by this method cost from 40 to 50 cents per acre. Experiments with the cylinder disk, or the wheatland plow, showed that it is not well adapted to typical Black Belt soils, except where previous cultivation has left the land in good tilth. This was due to its lack of penetration. The plow is entirely satisfactory for sandy or loam soil. It can be operated at a fuel and labor cost of 20 or 30 cents per acre. Twenty to 25 acres can be plowed per day. It is necessary to have a 15 to 20-horsepower tractor or its equivalent to operate the 8-foot wheatland satisfactorily on the sandy or red Piedmont soils tested. A method of cutting oats and planting peas at the same operation was developed by pulling the binder, wheatland plow, and grain drill with a 15-30 tractor. The labor and fuel cost was 23 cents per acre, and the peas were sown two weeks earlier than they could have been if the oats were shocked in the field. The curing of pea vine hay in the windrow with the side delivery rake was found to be economical of labor and to produce a high quality of hay.

A test of snapping cotton at Decatur showed this method to be applicable to conditions in that vicinity. Savings of from $2 to $4 per bale were shown after a slight loss for grade was deducted. Over one-half the time of gathering was saved. Tests with the new shave plow showed it to be satisfactory for sandy or loose soil, free from rocks, roots and large gravel. The capacity is approximately twice that of a 12-inch moldboard plow. It can be pulled by two 1,200-pound mules.

The W.S.C. Laying House, J. S. Carver and L. J. Smith (Washington State College (Pullman) Extension Bulletin 160 (1930), pp. 18, figs. 10).—This laying house is described and illustrated and practical information given on its construction.

The Use of a Small Electric Motor in Silo Filling, E. E. Brackett and E. B. Lewis (Nebraska Station (Lincoln) Circular 42 (1930), pp. 10, figs. 3).—An account is given of experience in silo filling with small electric motors on three Nebraska farms, indicating the utility of the 5-horsepower motor for such work where the silage is elevated as high as 37.5 feet. However, the results indicate that to use the small motor efficiently the farmer must have a silage cutter with a drum of large diameter and a fan that revolves in such a manner that the edges and sides of the blade clear the drum by a very small allowance. In addition the blower pipe should not be over 6 or 7 inches in diameter. Not over 30 tons of silage should be cut before sharpening and readjusting the knives. The knives must be set up as close to the shear plate as possible without striking, and the speed of the cutter must be as low as possible to elevate to the necessary height.

Terracing Farm Land in Georgia, O. E. Hughes (Georgia Agricultural College (Athens) Bulletin 394 (1930), pp. 22, figs.

13).—Practical information is given on the laying out and construction of terraces for farm land.

[Agricultural Engineering Investigations at the Arkansas Station] (Arkansas Station (Fayetteville) Bulletin 257 (1930), pp. 14-16, figs. 2).—D. G. Carter reported that pressure-treated pine and galvanized steel vineyard posts showed no deterioration after 7 years' use, painted steel posts were rusted but sound, and unseasoned, butt-treated oak posts had all failed at 6 years. Cured native oak posts with 24-hour butt treatment in hot and cold creosote bath failed 3.1 per cent at 5 years, 16.8 at 6, 28.06 at 7, 33.3 at 8, and 42.3 per cent at 9 years. Untreated oak and pine specimens, after 4 years in the ground, showed a failure of 65 per cent of the total. In the same period 12.5 per cent of the specimens with various preservative treatments had failed, practically all of these failures occurring in the fourth year.

Studies by B. S. Clayton and Carter on rice irrigation, conducted in cooperation with the U.S.D.A. Bureau of Public Roads, showed that a total depth of from 27 to 30 inches of water, including rainfall during the season, will irrigate a crop of rice. A rate of flow of 1 cubic foot per second, or 450 gallons per minute, for each 80 acres irrigated is recommended. The total cost of pumping varies from $10 to $12 per acre for lifts of 100 feet. For fields of 150 acres or less electric power is usually more economical, and for fields above 160 acres the oil engine furnishes the cheaper power. Over-all plant efficiencies of from 55 to 60 per cent could be generally attained by careful tests of new wells.

Brief data are also included on factors in farmhouse planning and on farm building costs.

Poultry House Heater Helps Egg Production, O. E. Robey (Michigan State (East Lansing) Quarterly Bulletin, 13 (1930), No. 2, pp. 78-80, figs. 2).—The conversion of a brooder stove into a poultry house heater is briefly described and illustrated.

Simple Burglar Alarm Protects Poultry, O. E. Robey (Michigan State (East Lansing) Quarterly Bulletin, 13 (1930), No. 2, pp. 48, 49, fig. 1).—An electrical burglar alarm for poultry houses is briefly described and illustrated.

[Building Materials Investigations at the Porto Rico Station] (Porto Rico Station (Mayaguez) Report 1929, p. 3, figs. 7).—Pise de terre has been found not to stand up well under Porto Rican climatic conditions. The daily drying and dampening of the air tends to disintegrate the clay, and the driving rains make it difficult to protect the outer surface of the wall.

Continued good results were had with soft limestone or coral deposit, locally known as "tosca," when hardened with cement. A mixture of only 1 part cement with 20 parts tosca set quickly and firmly. The surface of the combination may be hardened by brushing with cement in water or with water glass. A mixture of 1 part cement, 10 parts tosca, and 10 parts sand did not make as strong a construction as did the proportion of 1 to 20. The addition of small amounts of gypsum to the cement-lime mixtures increased their strength. The use of the fiber of the coconut husk as a binder reduced the cohesive properties of the mixture. The use of reinforcing irons in the mass was of no value because the mixture would not adhere strongly to them.

[Agricultural Engineering Investigations at the Oregon Station] (Oregon Station (Corvallis) Biennial Report 1929-30, pp. 73, 75, 113, 124).—Tests of four different makes of electric water-vapor sterilizers indicated that 175 F is the minimum sterilizing temperature.

Hay chopping tests with 5 to 10-hp motors as the source of power showed that the power required to chop hay and blow it into the barn was 3 to 4.25 kilowatt-hours per ton, and that 1 to 1.5 tons per hour could be chopped with the 5-hp motor. In silo-filling tests it was found that the power required to chop and blow silage into the silo was 1.3 kilowatt-hours per ton. Feed grinding tests indicated that the small hammer mill has been developed to the point that it has many advantages over the small burr mill. The coarse grinding of barley required slightly more power than coarse grinding of oats. Fine grinding of oats required slightly more power, however, than fine grinding of barley. The grinding of corn required less power than for either oats or barley.

The feasibility of supplemental irrigation in the Willamette Valley by use of deep wells was demonstrated by the installation of an 18-inch well, 155 feet deep, which developed a flow under continuous pumping of 2 cubic feet per second, or sufficient water to irrigate 160 to 200 acres of land.

The duty of water experiments indicated that the most profitable amounts of irrigation water for use under normal conditions in Harney Valley are for cereals 12 to 14 acre-inches; alfalfa, clover and field peas, 15 to 18 acre-inches; sunflowers, about 30 acre-inches; and potatoes, 10 to 14 acre-inches. In years of extreme drought these figures should be increased about 25 per cent.

World Agricultural Tractor Trials, 1930: Official report (Oxford: [University of Oxford, Institute of Research in Agricultural Engineering], 1930, pp. 109, figs. 34).—The results are reported of an exacting series of tests of 33 tractors and 3 power-driven market-garden cultivators conducted by the Institute for Research in Agricultural Engineering of the University of Oxford. The countries represented by the tractors were as follows: United States, 12; Great Britain, 8; France, 5; Germany, 4; Sweden, 2; Hungary, 1; and Ireland 1. Of the market-garden cultivators two were of British and the third of Swiss origin.

These results show that in both belt and drawbar tests there is a considerable variation among the different tractors in the amount by which the maximum power delivered exceeds the rated power as stated by the entrant. The average rated drawbar output is 78 per cent of the average maximum drawbar output, and the average rated belt output is 85 per cent of the average maximum belt output.

The results with paraffin tractors indicate that while the design of tractor engines running on paraffin may have reached a high state of efficiency, it is one which is not likely to be greatly improved upon in the near future. The results so far as belt fuel consumptions and costs are concerned did not differ very much from one another. In the drawbar fuel consumptions also, while one or two machines gave rather lower figures, there was little to choose between the performances of the majority of the machines. There was an obvious tendency for the weight per unit power to decrease as the comparative rating of the tractor increased.

Of the gasoline-burning tractors there was very little to choose between the fuel consumptions of the majority of the machines both on belt and drawbar. While this is partly due to the fact that five of these machines are products of the same firm, yet it appears that a high standard of efficiency has been attained by designers generally. The costs of fuel per 100 horsepower hours were considerably higher than for those in the paraffin group on account of the higher price of gasoline. No very marked variations from the average weight per maximum drawbar horsepower were evident.

The fuel oil tractors were all of the wheel type and fell into two classes, i.e., those with semi-Diesel or hot-bulb engines and those with full-Diesel engines. There was only a small variation in fuel consumption among the full-Diesel engines. The average fuel costs per 100 horsepower-hours showed a very large saving over those in both the paraffin and gasoline groups. However, the average cost of lubricating oil for the same power output was higher than for any other type. In the semi-Diesel machines there was more variation in fuel consumptions and the averages were higher than for the full-Diesel machines, but there was a distinct saving in fuel costs over both gasoline and paraffin machines. The average consumption of lubricating oil was not so high as for the full-Diesels. In both full-Diesel and semi-Diesel machines the weights per maximum drawbar horsepower were distinctly higher than for those of the other wheel type machines.

An illustration of and specification for each machine tested is given in a final section, together with a brief extract from the results of its test.

Fire Safeguards for the Farm, V. N. Valgren, H. E. Roethe, and M. C. Betts (U. S. Department of Agriculture, Farmers' Bulletin 1643 (1930), pp. II + 22, figs. 4).—This bulletin supersedes Farmers' Bulletin 904. It tells how to avoid or lessen fire hazards on the farm, describes simple fire-extinguishing equipment, and points out the need for organized and well-equipped rural fire departments.

Housing Farm Poultry, W. C. Tully (North Dakota Agricultural College (Fargo) Extension Circular 92 (1930), pp. 12, figs. 2).—Practical information is given on the subject with special reference to North Dakota conditions. Working drawings are included.

Irrigation Requirements of the Arid and Semi-Arid Lands of the Columbia River Basin, S. Fortier and A. A. Young (U. S. Department of Agriculture, Technical Bulletin 200 (1930), pp. 56, figs. 7).—This bulletin is one of a series on the irrigation requirements of the arid and semi-arid lands of the western states, and deals with that portion of the Northwest which is drained by the Columbia River and its tributaries. A part at least of the investigations upon which it is based appears to have been conducted in cooperation with the Oregon, Washington and Idaho Experiment Stations, and with the Department of Agriculture of the Dominion of Canada.

Data are presented on the soils, climate, water resources, agricultural resources and irrigation practices in the basin, and on the amounts of water required for crops and the conditions influencing them. A bibliography of 34 references is included.

Silage and the Trench Silo, R. C. Miller and F. W. Christensen (North Dakota Agricultural College (Fargo) Extension Circular 93 (1930), pp. 42, figs. 27).—This bulletin reports experiments and farm experience in the design, construction and use of the trench silo, with special reference to North Dakota conditions. The findings are presented in terms of practical information and working drawings. Practical information also is given on silage and silage making.

Electricity on Maine Farms, C. H. Merchant ([Augusta]: Maine Department of Agriculture, 1929, pp. 24, figs. 5; abs. in Maine Station Bulletin 353 (1929), pp. 141-143).—This bulletin lists the uses of electricity on Maine farms and discusses the energy required for operating the more common mechanical equipment. The results of a questionnaire survey of the use of electricity on 80 Maine farms are also reported and discussed. A report is also included on the use of electricity on an experimental electrified farm.

Distillate as a Tractor Fuel, H. F. McColly (North Dakota Agricultural College (Fargo) Extension Circular 94 (1930), pp. 8, fig. 1).—Studies are reported the results of which indicate that the first requisite for using distillate in tractor motors is that the motors operate smoothly on it. Motors having oiling systems of the internal circulating type should have a ventilated crank case.

One of the main factors governing the use of distillate is that its sulfur content should not be too high. The specification limit should permit not more than about 10 per cent more than that of kerosene, or 0.138 per cent sulfur in the distillate.

Distillate fuel costing 9 cents per gallon will save approximately 15 to 20 cents per hour in the fuel cost of the average three to four-plow tractor when compared with kerosene costing 15 cents per gallon. The savings in fuel costs by using distillate have in many cases been expended in repairs and adjustments, largely due to the damage done to the motor by excessive sulphur content in the distillate or improper motor adjustment and improper operation.

The Ground Water of Middle Rio Grande Valley and Its Relation to Drainage, D. W. Bloodgood (New Mexico Station (State College) Bulletin 184, 1930), pp. 60, figs. 22).—This bulletin is based on investigations conducted cooperatively by the U.S.D.A. Bureau of Public Roads, the state engineer of New Mexico, and the station. It reports investigations of the cause of the rise of the ground water table in the Middle Rio Grande Valley and of its behavior, and presents information obtained as to plans for reclamation.

It was found that soil structure and texture influence the fluctuation of the ground water. In tight soils the fluctuation is less than in the more porous soils. The ground water slope appears to flatten out in the more porous soils. The ground water table is lower in the heavier sandy loam soils than in the sandy soils. The crests and troughs of the lateral underground water are spaced more uniformly in the more porous soils than in the tighter textured soils. The general effect of the heavier soils of clay or clay loam on the ground water table is negligible. The ground water slope conforms generally to surface topography, regardless of soil texture. Precipitation, evaporation and temperature appear to have little or no influence upon the fluctuation of the ground water, but there is direct relationship between variations in river surface levels and the fluctuations of the ground water table.

West of the Rio Grande, 64 per cent of the seepage water was from the river and 36 per cent from the foothill area, while east of the Rio Grande 58 per cent of the seepage water was from the river and 42 per cent from the foothill area. When the ground water once becomes high it is slow to recede, and natural underground drainage is not sufficient to lower the ground water quickly. Some preliminary data are given which might assist a drainage engineer in planning a drainage system.

Soil Erosion—a Local and National Problem, C. G. Bates and O. R. Zeasman (Wisconsin Station (Madison) Research Bulletin 99 (1930), pp. 100, figs. 63).—This bulletin reports the results of an investigation of soil erosion made by the station in cooperation with the Lake States Forest Experiment Station of the U.S.D.A. Forest Service. The region studied embraces three counties in the unglaciated section of southwestern Wisconsin, and to a very small extent the Minnesota territory adjacent, in the vicinity of Winona.

The results indicate that the most immediate and direct cause of destructive erosion is soil disturbance, that is, a disturbance of any kind of the natural balance between gravitation and the binding power of roots tending to hold the soil in place, and on the other hand the force of running water tending to move it.

The formation of deep gullies may nearly always be traced to a disturbance of soil on or at the foot of steep slopes of such a nature as to create a direct fall for any run-off which may be concentrated at that point. The checking of gully cutting requires that the fall and cutting power of the water be decreased until it becomes negligible. This is accomplished (1) by complete diversion of the water to another channel, (2) by providing an artificial channel at the fall such as a flume, or pipe, or even the sloping face of a dam, or (3) by raising the level of the floor of the gully by means of soil-saving dams. Sheet erosion is primarily the result of the soil disturbance which attends any form of cultivation. The most certain preventive of erosion is to keep the soil continuously covered with vegetation.

From all the evidence available on conditions of run-off in southwestern Wisconsin, the belief is expressed that the economic interests of the individual farmer and of the community would be best served if it were required that all slopes of more than 25 per cent gradient be kept in timber and protected from fire and overgrazing, and if slopes of greater gradient than 15 per cent were only rarely plowed.

It is also considered best to terrace pastures with rather deep terraces not provided with outlets, to fertilize pastures and build up the humus content of the soil, and to avoid "puddling" of the surface of pastures, which results primarily from trampling, by keeping stock off the ground when wet, especially in the early spring.

Selection and Management of Kerosene Cook Stoves, E. B. Snyder (Nebraska Station (Lincoln) Circular 41 (1930), pp. 14, figs. 4).—Practical information is given in this circular regarding the advantages and disadvantages of the various types of kerosene cook stoves on the market. The types discussed are the long-chimney wick, short-chimney wick, short-chimney lighting-ring, and wickless stoves.

The Mechanical Dairy Cooler on Nebraska Farms, E. E. Brackett and E. B. Lewis (Nebraska Station (Lincoln) Bulletin 249 (1930), pp. 22, figs. 12).—The results of investigations of four installations of the walk-in type of mechanical dairy cooler are reported. No conclusions are drawn, but practical factors to consider when building a cold room are discussed.

[Agricultural Engineering Investigations at the Montana Station], H. E. Murdock et al. (Montana Station (Bozeman) Report 1929, pp. 18-23, figs. 7).—In the tractor farming study 120 individual mechanical tests of 11 tractors and a great variety of farm implements indicated that for efficient work these tractors should be operated at about their rated power capacity. At such full-load capacity the fuel cost per acre is at the minimum and the acres covered per hour at the maximum, thus reducing labor, overhead, interest and depreciation costs per acre.

Investigations of haystack weight and measurement, involving 600 stacks of hay, resulted in the development of a volume formula $\mathbf{V} = (\mathbf{W} \div 2)\,[\mathbf{O} - (5\mathbf{W} \div 6)]\,\mathbf{L}$, in which **V** is the volume in cubic feet, **W** is the width, **O** is the over, and **L** is the length of the stack in feet. For the average stacks as built in Montana this formula gives the volume within 1 per cent of the correct value for 45 per cent of all stacks measured. Eighty-one per cent of all stacks measured fall within 2 per cent, and 96 per cent of all stacks measured fall within 3 per cent of the value calculated.

A study of irrigated versus dry farming below the ditch showed that when the overhead cost per acre is not increased by high water charges, most farm crops can be produced at a lower unit cost with the aid of irrigation than where water is not used.

Data on tractor hitches are also included.

Sources of Power on Minnesota Farms, W. L. Cavert (Minnesota Station (St. Paul) Bulletin 262 (1930), pp. 72, figs. 3).—The results of a questionnaire survey of sources of power on 541 Minnesota farms are presented and discussed in detail. These indicate that horses are the most important source of power from the standpoint of horsepower-hours actually utilized in the farm business. Next are the tractor, the automobile, the truck, the stationary gas engine, electricity, and the steam engine. Considering the total power used in the farm business and by the farm family, the automobile is more important than horses. Of the total power used by the farmer and his family on 538 farms, about 30 per cent was furnished each by the automobile and by horses, nearly 25 per cent by tractors, about 7 per cent by trucks, 5 per cent by stationary gas engines, and less than 3 per cent by electric motors and steam engines.

Operating Ensilage Cutters and Husker-Shredders with Electric Motors, T. E. Hienton (Indiana Station (La Fayette) Circular 174 (1930), pp. 4, figs. 3).—The results of tests of 13-inch silage cutters to determine the practicability of driving them with a 5-horsepower motor are briefly reported. The results indicate the necessity of using sharp knives and changing them twice daily. They should be set so as to run as closely as possible to the shear plate without striking it. The shear plate should be replaced when the edge becomes worn or rounded off. The motor should be of 5-horsepower capacity, 1,800 rpm, 220 volts, single-phase unless 3-phase service is available, and 60-cycle unless other must be used. A 7.5-horsepower motor may be advisable where 16-inch or larger cutters are used, but should be avoided because of usual additional capacity charge. The speed of the cutter should be as slow as will elevate the corn into the silo at full load. The 12- or 13-inch cutter is best suited for use with the 5-horsepower motor. Larger cutters may be used where height of elevation is not great, but only with very careful feeding. The clearance at the tip of the fan wings should not exceed 0.125 inch and at the sides not over 0.5 inch.

Tests of husker-shredders indicated that a 2-roll machine was the largest size which could be operated by a 5-horsepower motor. Very little additional capacity could be secured by using the 7.5-horsepower motor with this particular machine.

"Proceedings of the World Engineering Congress" (at Tokyo, 1929) has been published complete in 39 cloth-bound volumes. The paper by H. B. Walker, A.S.A.E. representative at the Congress, entitled "Engineering as Applied to Agriculture," is included in Vol. 25, Mechanical Engineering, Part I. These "Proceedings" are edited and published by the World Engineering Congress and distributed by Kogakkai, Marunouchi, Tokyo.

"Tractor and Implement Blue Book, 1931," the twenty-ninth annual edition of this indexed and classified directory of farm equipment manufacturers, with specifications for some types of machinery and with data useful in its application, is available from the publisher, Midland Publishing Co., St. Louis, Mo., at 50 cents per copy.

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Chemistry and Agricultural Prosperity

A CURRENT economic survey sees in the making a better balanced prosperity than that which followed the depression of 1921. It bases its hopes on no one particular industry or impending development but on the aggregate influence of numerous minor improvements, largely the achievements of research.

For example, it points to the almost unlimited possibilities of industrial chemistry and suggests that its developments may make the farmer a producer of industrial raw materials as well as of the materials for food and clothing. This is, of course, no new idea to agricultural engineers as we have kept an eye on all developments along this line. But its mention suggests re-emphasis of its significance to agricultural prosperity and to our profession.

If agriculture is ever to become a growing, dynamic industry—one that will not feel distress and have to forcibly throw off man-power with every increase in efficiency—it must find new markets for its products, new ways of developing and commercializing its resources. Chemistry is giving it more help in this direction than any other science. The products of agriculture are essentially complex organic chemicals capable of being broken down and recombined into substances with an almost unlimited variety of physical and chemical properties. Technical progress in chemistry is sure to bring these farm-grown chemicals to the front to compete with or outclass, in the economic race, many of the other resources of nature. It will also continue to create new, unheard of useful compounds and to discover new uses for little-used substances.

While chemists will lay the foundation for this new phase of agriculture, agricultural engineers have a substantial share of the responsibility for seeing that the ever-growing list of human wants is supplied, so far as is economically feasible, from agricultural resources.

The chemical and fiber industries know what they want, in the way of raw materials, and what they can pay for them. Organic chemists know the composition and structure of most biologic products. Biologic scientists know the production capacities, conditions, limitations and other characteristics of plants and animals, both those common to farms at present and others not now classed as agricultural. Agricultural engineers know the production problems of farmers; the problems of increasing their efficiency; and the difficulties of changing their organization, products and methods. Are not agricultural engineers the logical ones to take the initiative in coordinating the efforts of all these groups with a view to building up the commerce between agriculture and the industries, for the sake of creating a better balanced, mutual prosperity?

Contacting Leading Farmers

A LEADING farmer who recently traveled 3000 miles through twelve states in company with an agricultural engineer declares that the American Society of Agricultural Engineers meeting at Ames was the high point of the trip.

And the agricultural engineer in the case suggests that, if other agricultural engineers in the colleges, state experiment stations and federal department of agriculture would take the trouble to bring their prominent farmer friends with them to A.S.A.E. meetings, they would find their work better understood and supported.

This is a valuable suggestion. It might apply as well to the men in the industries, or to any agricultural engineer in any position. To what farmer would you most like to give a clearer understanding of your work? Bring him with you to the next A.S.A.E. meeting.

Single Court of Patent Appeals

THE American Engineering Council committee on patents has submitted to the A.S.A.E. Council a report highly favorable to the establishment of a single court of patent appeals. It recommends support of legislative action in this direction and submits a proposed bill for the establishment of such a court under provisions deemed to be in the best interest of the patent system.

As shown by the report the present system of handling patent appeal cases in the U. S. Circuit Courts of Appeals involves a multiplicity of litigation, expense and general dissatisfaction which largely nullifies in application the advantages of the patent principle. The evil is an old one, but still growing with the increasing complexity of scientific and engineering development. Efforts to establish the single court date back to 1903. If there is any substantial argument against it, it is not revealed in the report.

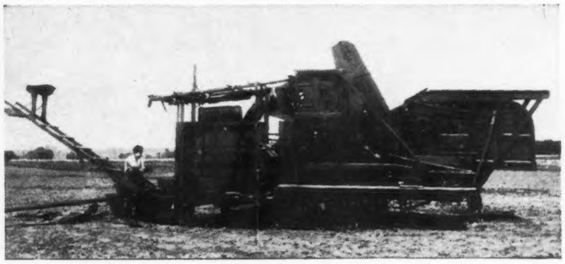
This is a matter which influences agricultural engineers as inventors and patent holders; as professional employees of interested manufacturers; and as potential beneficiaries of the development of materials and equipment which would be accelerated under more encouraging conditions. The A.S.A.E. has been invited to consider and express its opinion on the matter before October when the American Engineering Council will probably decide whether or not to support the proposed legislation. The opinions of individuals who have had experience in patent litigations or who will study the proposition, will be helpful.

Farmer Training for Engineered Agriculture

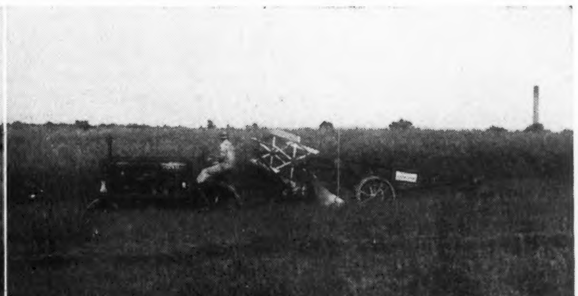
THE kind of training needed by farmers in modern agriculture is well pictured by analogy in the editorial notes of the April number of "The Implement and Machinery Review" (London). Says the Review ". . . . . . It is not demanded . . . . . . that British farmers shall become engineers in the strict sense of the word, but it is asked that they shall be given full opportunity to understand and apply implements and machinery in an intelligent and competent manner. This is not an exorbitant demand. In the past, for example, a farmer has been able to give his horses all the care necessary to get the best out of them without himself being a veterinary surgeon, and surely he can arrive at a similar stage with regard to machinery without being compelled to be an engineer. The specialist in either direction is at his beck and call when required."

A.S.A.E. and Related Activities

Pageant Pictures



(Upper left) Replica of the original McCormick reaper. Second, third and fourth from the left, in the order named, are J. B. Davidson, first president of A. S. A. E., R. W. Trullinger, president for the year 1930-31; and Cyrus McCormick, Jr., grandson of Cyrus Hall McCormick, the inventor. (Above) The old "Holt" wood-frame ground-drive combine—survivor of the machines which made combine history on the Pacific Coast. (Left) Event No. 17, showing the army of workers released from the slavery of hand-harvesting methods by a modern combine and tractor. (Next lower, left) The Marsh Harvester, with two men sweating to keep the bundles tied. (Right) A modern windrower. (Lowest left) A power-take-off operated binder. (Right) A modern horse-drawn combine



Virginia Polytechnic Institute Observes "McCormick Day"

HONORING a native son, Cyrus Hall McCormick, on the 100th anniversary of the summer when he gave the world the first practical horse-powered grain reaper, the State of Virginia held, on July 29, at Virginia Polytechnic Institute, a program appropriate to the occasion.

The program opened at noon with a luncheon for invited guests and a general dinner for other visitors, both in the college dining hall. These were followed by a band concert, a showing of the motion picture "The Romance of the Reaper," the official opening of an exhibit of working models of McCormick harvesting machines, a public program of addresses, an outdoor barbeque supper, a repeat showing of "The Romance of the Reaper," singing of old songs at the stadium, and a pageant portraying the evolution of grain harvesting methods and equipment from the earliest historical period to the present.

Hon. James P. Woods, member of the board of visitors of the Virginia Polytechnic Institute, presided at the program of addresses. Dr. George E. Vincent, president of the Rockefeller Foundation, spoke on "The Place of the Exceptional Man in a Democracy." "The Influence of Cyrus Hall McCormick's Invention and Constructive Genius on World Agriculture," was the subject of an address by Alexander Legge, president of International Harvester Company and chairman, until recently, of the Federal Farm Board. Cyrus McCormick, Jr., grandson of Cyrus Hall McCormick, covered in his address the "Development in Farm Machinery Since 1831."

Model machines exhibited included an interesting and highly complete series of working models beginning with the Gallic stripper of the first century and running down through the McCormick developments to the present. A diorama depicting in miniature the first public trial of McCormick's reaper was also on display for its premier showing in America.

More than 300 characters, carefully trained, directed and costumed, had parts in the pageant, in which old machines and full-sized models were shown in operation across a 60-foot stage.

Zinc Institute Adopts "Seal of Quality"

A "SEAL OF QUALITY" to be stenciled on galvanized sheets, and to specify the weight of the zinc coating carried, has been adopted by the American Zinc Institute. It is hoped that this seal, supplemented by an educational program, will result in raising and standardizing the quality of commercial galvanized sheets.

For use in rural communities, particularly for roofing and siding of farm buildings, such sheets will be produced in 28 and 26 gage, with a coating of 1.75 ounces of zinc per square foot. This coating is fully 40 to 100 per cent heavier than coatings on most of the commercial sheets produced today, and will preserve the sheets from rust for a far longer period than the thinner coatings. For use in localities where atmospheric conditions are more severe, sheets of 26 gage and heavier, carrying 2.00 to 2.50 ounces of zinc per square foot, will be produced. These heavily coated sheets will be sold mainly in the corrugated and V-crimp types, for use in roofing, siding and similar applications. Such sheets should not be subjected to severe bending or extreme forming operations unless special measures are taken to prevent damage to the coating.

Use of the seal will be limited to licensed manufacturers, whose products will be continually subject to checking by the Institute as to the standard of coating. The manufacturer will also stamp his product with his own name or trade-mark.

Technical Division Plan Winter Meetings

AT THE twenty-fifth annual meeting of the A.S.A.E. in June, a consensus of opinion in each of three of its technical divisions favored the holding, by those divisions, of technical meetings during the coming winter.

Two of the divisions, Power and Machinery and Structures, will undoubtedly follow their usual practice of holding their meetings in Chicago during the first week in December, the week of the International Livestock, Hay and Grain Shows.

The Land Reclamation Division, which also decided to meet this winter, has not yet definitely selected a time and place, but are considering meeting in Chicago in conjunction with the other divisions.

Personals of ASAE Members

F. C. Fenton, professor of agricultural engineering and **C. A. Logan**, assistant professor of agricultural engineering, Kansas State Agricultural College, are authors of "Farm Grinding of Grain and Rye," which is published as Kansas State College Bulletin, Vol. XV, No. 7, May 1, 1931.

L. G. Heimpel, assistant professor of agricultural engineering, Macdonald College, McGill University (Quebec, Canada), is author of a paper entitled "Reducing Costs of Production by Means of Machinery," which appeared in the May issue of "Scientific Agriculture," and which has been reprinted in bulletin form.

Applicants for Membership

The following is a list of applicants for membership in the American Society of Agricultural Engineers received since the publication of the May issue of AGRICULTURAL ENGINEERING. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

George C. Bartells, Field and Laboratory research work, American Zinc Institute, Inc., New York City.

Mark R. Kulp, Asst. Prof. Agricultural Engineering, University of Idaho, Moscow, Idaho.

George R. Mellema, Supervision over research work in field and factory, Clay Equipment Corporation, Cedar Falls, Iowa.

Bernard C. Taylor, Rural Department of Central Illinois Public Service Company, Springfield, Ill.

David L. Yarnell, Senior Drainage Engineer, Bureau of Agricultural Engineering, U. S. Department of Agriculture, Iowa City, Ia.

Transfer of Grade

Wesley A. Harper, Agricultural Sales Bureau, Caterpillar Tractor Company, Peoria, Ill.

EMPLOYMENT BULLETIN

An employment service is conducted by the American Society of Agricultural Engineers for the special benefit of its members. Only Society members in good standing are privileged to insert notices in the "Men Available" section of this bulletin, and to apply for positions advertised in the "Positions Open" section. Non-members as well as members, seeking men to fill positions, for which members of the Society would be logical candidates, are privileged to insert notices in the "Positions Open" section and to be referred to persons listed in the "Men Available" section. Notices in both the "Men Available" and "Positions Open" sections will be inserted for one month only and will thereafter be discontinued, unless additional insertions are requested. Copy for notices must be received at the headquarters of the Society not later than the 20th of the month preceding date of issue. The form of notice should be such that the initial words indicate the classification. There is no charge for this service.

Men Available

AGRICULTURAL ENGINEER, with degree from Illinois 1927 and with one year's experience as county farm advisor and three years in rural electrification work with an electric power company, desires permanent connection either in a college or in rural service department of an electric utility or appliance company. Age 29. Good health. Single. MA-200.

AGRICULTURAL ENGINEER desires position in experimental, sales or service of farm machinery, or teaching agricultural engineering. Degree from University of Illinois 1927. Two years' teaching agricultural engineering, one year selling power farm machinery, five months as research assistant in state university; practical farm experience. Age 25. Single. MA-201.